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Monterey, California



THESIS

THE EFFECTIVENESS OF TACTICAL
ADAPTATION
AND COORDINATION TRAINING ON TEAM
PERFORMANCE IN TACTICAL SCENARIOS

by

Lonnie R. Green

June, 1994

Principal Advisor:
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William G. Kemple

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THE EFFECTIVENESS OF TACTICAL ADAPTATION
AND COORDINATION TRAINING
ON TEAM PERFORMANCE IN TACTICAL SCENARIOS

by

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

from the


NAVAL POSTGRADUATE SCHOOL


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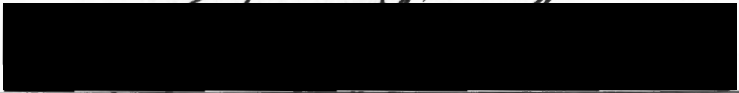
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ABSTRACT

In Command and Control, decisions require the fusion of inputs from a number of subordinate decision-makers during the situation assessment process. The tactical operating environment often introduces stress into the team's decision-making process. The Office of Naval Technology in Arlington, VA has sponsored research under the Tactical Decision-Making Under Stress (TADMUS) program to study ways to minimize the degradation to the teams' effectiveness during these periods. Under the TADMUS Project, the Tactical Adaptation and Coordination Training (TACT) experiment was designed by Alphatech, INC. to test theories on individual and team training techniques that were hypothesized to mitigate the effects of stress during tactical situations of interest (high and low stress scenarios).

In a detailed review of the data gathered during the experiment, it is concluded that the training strategies were indeed effective in significantly altering the subject teams ability to perform under the test conditions. Additionally, there were no conclusive findings that the level of stress, as presented in the experiment, had a significant effect on the performance of the teams.

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I. INTRODUCTION

A. BACKGROUND

In the Navy/Marine Corps White Paper ...*From the Sea*, a fundamental change in strategy away from a focus on a global threat to a focus on regional challenges and opportunities is presented by Navy leadership as a result of a fundamental shift in the national security policy. As Joint Task Force members, Naval Forces will be full participants in the principal elements of the *National Security Strategy*--strategic deterrence and defense, forward presence, crisis response, and reconstitution. Maritime forces are particularly well suited for the forward presence and crisis response missions which would likely be conducted in the complex operating environment of the "littoral" or near the coastlines of the world. In shifting away from open-ocean warfighting on the sea, the leadership has recognized that if forces are to be successful they must be trained and equipped to make near instantaneous correct decisions. Commanders will be making those decisions while operating task forces constrained by less room to maneuver and a far shorter reaction time to a wider range of more lethal threats.

In littoral regions, friends, adversaries, and neutrals are all operating within confined and congested water and

airspace. The normal density of contacts encountered while operating near land makes identification and situation assessment extremely difficult for the forces. (O'Keefe, Kelso, and Mundy, 1992) As a result of the probable need to deploy forces into difficult operating environments, where mistakes can be catastrophic, the Navy has pursued programs designed to improve tactical decision-making and performance in stressful situations.

The Tactical Decision-Making Under Stress (TADMUS) program was initiated in an effort to better understand how tactical decisions are made during high stress periods, when commanders often are faced with grave consequences as a result of incorrect decisions, which are often made based upon ambiguous data and uncertain information. Past programs concentrated on providing more time for decision making by speeding up the processing, dissemination and displaying of information. (Smith and Grossman, 1993) The TADMUS program's primary objective is to apply recent developments in decision theory, individual and team training, and information display to the problem of enhancing tactical decision quality under conditions of stress. The following five tasks comprise the program's objectives:

1. Definition and measurement of critical decision tasks.
2. Examination of stress effects on decision-making.
3. Development of decision support principles.
4. Development of training and simulation principles.

5. Development of display principles.

The program consists of two projects; both of which are sponsored by the Office of Naval Technology, which is located in Arlington, VA. Project RM33T40 is principally concerned with the development of decision support principles and display principles for decision support systems. Project RM33T60 is principally concerned with development of training and simulation principles to counteract stress. This thesis reports on the Tactical Adaptation and Coordination Training (TACT) experiment which was designed to test teamwork, coordination, and adaptation training strategies in support of completing task objective four. (Malecki and Collyer, 1992)

B. PURPOSE

1. Tactical Decision-Making In A Combat Environment

In recent history, catastrophic incidents such as the one involving the USS Stark and later the USS Vincennes have focused attention on the human factor in decision-making under stressful conditions. In retrospect, it is now acknowledged that improved training and support must be provided to the decision-maker to aid him in sorting through confusing situations where it is often not clear who the enemy is or what his intentions may be. (Malecki and Collyer, 1990) The TADMUS project was initiated to explore methodologies to improve the decision-making process in teams under stress. The TACT experiment is one in a continuing series of TADMUS

program experiments. TACT was specifically designed to test theories on individual and team training techniques that were hypothesized to increase team performance during periods of high stress. Using the Decision-Making Evaluation Facility for Tactical Teams (DEFTT), information processing similar to that of an actual AEGIS cruiser combat information center (CIC) environment was simulated. Based upon variations in levels of training and differing levels of stressful scenarios, the DEFTT lab was used to measure the effect of the training techniques in question and their ability to improve team performance versus selected measures of performance. (Malecki and Collyer, 1992)

2. Questions

The TACT experiment was designed to test the efficacy of training techniques aimed at enhancing teamwork skills and providing team coordination and adaptation strategies. The coordination and adaptation strategies would be tested to see if they helped the teams maintain their level of performance in the face of stress. The particular research questions are as follows:

1. If team members are taught to monitor other team members and offer assistance during periods of high stress (presence of heavy workload on a team member) will the teams' overall level of performance improve?
2. If teams are given a technique to achieve a shared mental model of the current tactical picture, such as structured TAO situation assessments, would their performance level be improved?

Additional questions of interest for this thesis are:

1. Does an analysis of the experiment provide insight into the decision making process that can be used to improve the effectiveness of the training?

2. What can be done to improve the TACT experiment?

3. Approach

For the TACT experiment, the overall approach was to identify appropriate candidate adaptation and coordination strategies; test those strategies in a laboratory setting; and then evaluate the effectiveness of those strategies. After two hours of initial DEFTT lab orientation training, which included individual workstation familiarization, the teams engaged in two practice scenarios where they were allowed to interrupt and ask questions. Prior to running each new scenario, there was a scenario prebrief which included specific tasking and a current situational update for the upcoming scenario. Upon completion of the scenarios, test subjects were given questionnaires which were used to gather data on their reactions to the scenarios in terms of the level(s) of stress that were present and their perceived task workload. Once the familiarization runs were completed, each team participated in two combat scenarios, one low stress and one high stress. Observations of the teams' performance were recorded using audio, video, and written observer rating forms. Training intervention was then conducted, immediately followed by two combat scenarios. The data obtained in the

later two simulations was compared to data obtained in the first two simulations to determine the effectiveness of the training. Minitab, a computer based statistical package, was later used as the prime analysis tool in an attempt to measure significant differences in the levels of observed performance of the teams as a result of receiving intervention training.¹

4. Anticipated Results

It was hypothesized that the coordination and adaptation training strategies that were tested in the TACT experiment would be effective in counteracting the negative effects of stress and would thus improve team performance during periods of high stress. The overall premise was

well trained teams cope with stress through internal mechanisms of decision strategy adaptation, coordination strategy adaptation, and structural reconfiguration, in an effort to keep performance at a required level while maintaining stress below an acceptable threshold (Serfaty, Entin, Deckert, and Volpe, 1993).

The experiment was designed to look at the following specific points and their relationship to managing the effects of stress:

1. Training for implicit coordination.
2. Training for team adaptation to stress.
3. Periodic sharing of the TAO's assessment of the situation.
4. Enhancement of the team's structural flexibility.

¹ Minitab was the computer-based statistical analysis software package of choice used by the author.

If the experiment is successful, then it will have demonstrated that teams in a laboratory setting can be trained to recognize the presence of stress, reconfigure their structure(s) and adjust their strategies in order to maintain an acceptable level of performance when operating in a tactically challenging environment.

a. Support for anticipated results

Review of the literature suggests that teams use explicit coordination during periods of low stress and implicit coordination during periods of increasing stress. Explicit coordination requires more communications as team members generally respond to requests for information etc. from others as they coordinate their efforts. During periods of stress, implicit coordination becomes the desired norm. This strategy requires team members to become familiar with others needs; to be able to anticipate requests and respond or provide support without prompting. Implicit coordination relies upon team members having a shared mental model of the situation.² The team members are then able to anticipate the needs and desires of others that are related to managing the crucial task(s) of the moment and they will thus refrain from introducing noise to the situation assessment and decision-making process. (Serfaty, Entin, Deckert and Volpe, 1993)

² A detailed discussion of the importance of teams having a common shared mental model is presented in Rouse, Cannon-Bowers and Salas (1992).

During the TACT experiment, the TAO is prompted to periodically share his assessment of the tactical picture in order to provide the appropriate mental model which is required for implicit coordination. After the TAO provides his assessment, members then only need to communicate relevant information that deviates from his assessment.

The literature also suggests that teams should maintain the flexibility to restructure when faced with stress. The hypothesis is that with effective cross training and functional task familiarization, superior teams will be able to reconfigure their structure to support members who are experiencing task overload at their workstations. This strategy should enable the team to regulate the workload imposed by the external stressors. (Serfaty, Entin, Deckert and Volpe, 1993) During the TACT experiment, use of this technique was encouraged and thus subsequently observed being used.

C. EXPERIMENTAL PARTICIPANTS

The TACT experiment was conducted at two sites. Students from the Joint Command Control and Communications (JC³) curriculum at the Naval Postgraduate School (NPS) in Monterey, CA and personnel from the Surface Warfare Officers' School

Command in Newport, RI participated as test subjects.³ The experiment was run by contract personnel from Alphatech, INC. and representatives from the Naval Training Systems Center, Orlando, FL. At NPS, student participants were divided into six teams with five members each. Two teams acted as the control group, two teams received TACT training and the remaining two teams received, TACT and information structure training. Each subject group had five operator positions, tactical action officer (TAO), electronic warfare supervisor (EWS), anti-air warfare coordinator (AAWC), tactical information coordinator (TIC) and identification supervisor (IDS). The slate of operators reflected the current suite of key players in a typical Navy Aegis Combat Information Center (CIC). In addition to serving as test subjects, additional students assisted contractor personnel in the mechanics of running the experiment such as providing role play and completing subjective evaluations of team performance. At NPS a third group was responsible for reporting their interpretation of the data gathered during the experiment as a part of their study of the JC³ curriculum.

³ This thesis documents those activities observed at NPS Monterey, CA where the author was an experimental participant and student in the JC³ curriculum.

D. EXPERIMENT SCOPE

The DEFTT laboratory was used to conduct four simulations (two of high stress scenarios, two of low stress scenarios) to evaluate the effects of the adaptation and coordination training strategies. If the strategies prove effective in the laboratory tests, then those promising techniques would be further refined and subjected to additional testing in at-sea experiments. The effective strategies will eventually be developed into a series of recommended principles, guidelines, and methodologies for training tactical decision-making teams throughout the fleet. (Malecki and Collyer, 1990)

II. EXPERIMENTAL DESIGN

A. OVERVIEW

The TACT experiment was developed by Alphatech, INC. to test hypotheses regarding training interventions that would reduce the impact of stress on tactical decision-making. This four stage experiment used the DEFTT laboratory to provide realistic simulations of AAW scenarios. (Entin, 1994) In order to keep the scope of the experiment to a manageable size, six key positions were identified as those most critical to replicating the AAW decision-making process inside of a ship's CIC. The six positions which are supported by the laboratory are: commanding officer (CO), TAO, AAWC, TIC, IDS, and EWS.⁴ The lab also provides all of the necessary tactical cues required to support situation assessment and decision-making while it records the actions of team members for later analysis as they play through the presented scenarios. (Malecki and Collyer, 1992) Further details describing the setup, the hypotheses, assumptions, statistical design, measures and instrumentation are provided in the following sections.

⁴ The position of Commanding Officer was not utilized during the TACT experiment.

B. SETUP

The setup is comprised of the following four general categories: physical, test subjects, special equipment, schedule of trials.

1. Physical

The DEFTT lab was designed to provide good functional realism of an operational AAW environment. The setup consists of six IBM-AT 386 personal computers with Aegis display system, command and display system, and electronic warfare supervisor software modules. The six personal computers, which serve as operator workstations, are networked to a Hewlett-Packard 9000/345 experimental control station (ECS). The ECS generates and controls experimental scenarios, supports a multi-channel communications system, and runs a Barco Graphics Large Screen Display.⁵ An ideal (uncluttered) link picture with Naval Tactical Data System (NTDS) symbology is available to all of the operators via their personal computer workstations. (Malecki and Collyer, 1992)

a. Scenarios

The DEFTT scenarios are set in the Arabian Gulf area of operations. This geographic region is a particularly good setting for potential "real world" incidents due to its volatility and high density of contacts. The scenarios are

⁵ The system is capable of time-stamped recording of all verbal communications among team members.

filled with ambiguous situations which are often left unresolved for the team players. The experiment was designed to prohibit decisions that were made in a prior scenario from influencing decisions made in later scenarios. This design eliminated a need to provide feedback to teams on the consequences of their actions and the actions of any contacts of interest that were perceived as threats to the team. This technique was seen as increasing the realism of the scenarios since many real world encounters end with questions of true intent left unresolved.⁶ (Hutchins and Kowalski, 1993)

b. Task Demands

The scenarios were developed to provide a stressful environment for teams to be observed working within.⁷ They were designed to require completion of many complex tasks within short periods of time. Contacts of interest were blended in with neutral/unknown and friendly tracks, thus making the determination of their identity and intent a more complicated process. The uncertainty and ambiguity makes the required application of the rules of engagement (ROE) more difficult for the teams. Even in cases where engagement

⁶ The primary purpose of the experiment is not to judge teams regarding their right or wrong decisions, but rather to examine their ability to adapt and coordinate their actions when presented with ambiguous threatening scenarios.

⁷ For experimental purposes, the level of stress was manipulated through the use of two variables: environmental ambiguity and operator workload. (Entin, 1994)

criteria are met, per the correct application of the ROE, the more appropriate decision might be not to engage. Additionally, the workload on team members is increased by both internal and external communications requirements, while very little support from off-ship assets is provided to aid in clarifying any ambiguous situations. (Hutchins and Duffy, 1993)

2. Test Subjects

The six test subject teams were composed of five members each. The team members were tasked with filling five of the six key decision-making positions found in a typical Aegis CIC. All of the subjects were student members of the JC³ curriculum at NPS. The subjects represented all the services and included one civilian student from the National Security Agency (NSA). All teams had members with varying levels of military experience, but all of the appointed TAOs had significant Navy CIC operational experience. All of the officers were of the O-3 and O-4 paygrades. The subjects were unaware of which type of training they had received. Additionally, they were instructed not to discuss the experiment with the other teams until all teams had completed the experiment. This was done to prevent any potential compromise of the experiment.

3. Special Equipment

The primary equipment required for conducting the experiment was described in the physical setup. A VHS recorder was the only additional piece of special equipment that was not previously mentioned. The videotape recorder was used to support later analysis by recording scenario events from the TAO's large screen display and the associated communications (audio) that was occurring at the time amongst the team members.

4. Schedule

The experiment was divided into four phases and was conducted in the following sequence;

1. Stage 0 -- basic instruction and training for all teams.
2. Stage 1 -- pre-intervention data collection.
3. Stage 2 -- intervention training.
4. Stage 3 -- post-intervention data collection.

Intervention training, stage 2, consisted of one of the following three training levels:

1. CONTROL--No significant training or other pertinent information was provided. This served as a baseline for team comparison.
2. TACT--Subjects were taught to identify signs and symptoms of stress. Subjects were then taught several team strategies to adapt to stress with a focus on team coordination. Scripted video presentations, which demonstrated good and bad application of the team behavior strategies, were then viewed. Subjects were then allowed to practice what they had learned on the DEFTT simulator using two practice scenarios. To complete the intervention training, subjects viewed a summary videotape on the

importance/principles of teamwork presented by a retired Rear Admiral.

3. TACT and Information Structure (TACT plus)--In addition to the TACT training, the TAO was prompted every three minutes to provide a situation report (sitrep) over the network so that other workstations would understand his assessment of the overall tactical picture. Additionally, team members were instructed on how to interpret and best utilize the sitrep information.

At stage 0 (prior to commencing the experiment), each of the teams were provided two hours of training. This training consisted of task familiarization, two slide briefs, and a 30 minute proficiency run using the simulator. At stages 1 and 3, each teams' performance was observed and evaluated during both a high stress and a low stress scenario. Stage 1 data observations were then compared to stage 3 data observations for indications of the effectiveness of the training conducted during stage 2. (Entin, 1994)

C. HYPOTHESES

The primary purpose of the TACT experiment was to test the hypothesis that training can mitigate the negative effects of stress on team performance. The experiment specifically focuses on looking at coordination and adaptation strategies and whether or not they have the desired effect which is suggested by the theories set forth in Chapter I. The contractor designed the experiment to look at several different measures; anyone of which could be used to support accepting the premise that their proposed training strategies

did indeed effect team performance during periods of stress. (Entin, 1994) This thesis will limit its focus to only two of the five measures that are supported by the experiment and used by the contractor.⁸ The hypotheses of interest are:

H_{o1}: Training will not effect overall team performance.

H_{a1}: Training will effect overall team performance.

H_{o2}: Training will not effect teamwork.

H_{a2}: Training will effect teamwork.

D. ASSUMPTIONS

There were four predominate assumptions associated with the TACT experiment. First, DEFTT is a legitimate simulation of an actual Aegis CIC environment (Entin,1994).⁹ It is therefore a valid tool for testing the experimental condition(s) of interest (decision-making in an at-sea tactical environment during high and low stress periods). Another assumption was that after initial familiarization training, all teams were near the same level of competence and understanding of the functionality/buttonology of their respective watchstations. Therefore, once the testing began any learning curve effect would be negligible. Thirdly, the observers' ratings of team performance were quantitatively

⁸ A more complete listing of the measures will be provided later in the paper.

⁹ Experts have accepted DEFTT as a valid simulation of the higher level functional decision making process that occurs within an Aegis AAW environment.

consistent throughout the course of the experiment. The final significant assumption was that the subjects were willing and enthusiastic participants. This assumption was necessary since the subjects were not volunteers.¹⁰

E. STATISTICAL DESIGN OF EXPERIMENT

The statistical design of this experiment was modeled after Campbell and Stanley's Pretest-Posttest Control Group Design 4 (Entin, 1994). Design 4 (adapted by Alphatech, INC. for the TACT experiment) uses random assignment of training techniques to each team, in that the team conditions (i.e., control, tact, or tact plus) and when they would be exposed to differing experimental variables (i.e., low stress or high stress scenario) were assigned prior to the subjects being assigned to the teams. This randomization would likely further negate a potential compromise of the experiment that might take place if team members were to prematurely discuss their roles and the training scenarios which they had participated in. This experimental design also supports multivariate analysis which is capable of looking at more than one independent and/or more than one dependent variable. (Campbell and Stanley, 1965) The experimental schedule, is presented in the following table.

¹⁰ The author's personal observation was one of enthusiastic subjects who appeared to put forth their best efforts commensurate with their abilities.

Table I: EXPERIMENTAL SCHEDULE

| CONDITION | TEAM ID # | PRE-TRAINING | POST-TRAINING |
|---------------------|-----------|--------------|---------------|
| CONTROL | N5 | 2- 1+ | 2+ 1- |
| | N2 | 1+ 2- | 1- 2+ |
| TACT | N3 | 1+ 2- | 1- 2+ |
| | N1 | 1- 2+ | 1+ 2- |
| TACT & STRUCTURE | N6 | 2- 1+ | 2+ 1- |
| | N4 | 1+ 2- | 1- 2+ |

Table I depicts simulation assignments to the six teams involved in the experiment. A key for the table is provided below.

"1-" => scenario one, low stress
"1+" => scenario one, high stress
"2-" => scenario two, low stress
"2+" => scenario two, high stress

F. MEASURES

The TACT experiment used four methods of measuring team performance. The measurement instruments consisted of pre and post-mission questionnaires, the NASA Task Load Index (TLX), trained observers conducting performance assessments, and observers quantitatively measuring verbal communication rates. (Entin, 1994) Only that data collected as subjective measures of teamwork and team performance will be analyzed within this paper.

1. Pre-Mission Questionnaires

The pre-mission questionnaires were administered to subjects before and after intervention (stage 2) training. The questions were designed to assess the perceived congruence among team members of the same mental model of the tactical situation. (Entin, 1994) If the training was successful, then the after intervention training questionnaires should indicate an increased perception from members that they and the team are more likely to share the same mental picture of the situation as a result of applying the techniques suggested during the stage 2 training.

2. Post-Mission Questionnaires

The post-mission questionnaires were administered to subjects after each trial. The questions were designed to assess the level of confidence within the team, the amount of cross-monitoring of teammates workload (increased awareness of the presence of stress) and whether the level of assistance and anticipation of other members needs had increased. When combined with the pre-mission questionnaires, the post-mission questionnaires formed the basis for a subjective self assessment of team performance. (Entin, 1994)

3. Subjective Workload

The NASA TLX was used to determine the workload that subjects felt they were exposed to during the course of the experiment. This rating procedure relates workload to

demands imposed on the subject and to the interaction of the subject with the task. The TLX responses are combined to produce overall weighted workload scores. (Hutchins and Kowalski, 1993) This measure could then be used to look at perceived subject workload as it relates to stress level and if the member's perceived workload was reduced as a result of being exposed to stage 2 training strategies. The implication would be that with a reduction in the perceived workload, as a result of the intervention training, an acceptable level of performance will be maintained.

4. Teamwork and Performance

The subject teams were rated by two trained observers. The observers graded teamwork on the basis of 15 individual items which were deemed to be appropriate indicators of teamwork. The combined items are referred to as the AAW Team Observation Measure (ATOM).¹¹ In addition to the teamwork ratings, the observers were also evaluating the teams'

¹¹ ATOM is a team process measure. It was developed based upon a critical incident approach and refined during workshops. Dimensions of the AAW team process include: communication, team orientation, team leadership, monitoring, backup, feedback, and coordination. These behaviors are scored on a scale from 1 to 7 for each event in the scenario. Note: the team leadership dimension was not evaluated during the TACT experiment. (Malecki and Collyer, 1992)

performance on the basis of the 12 individual items which are referred to as the AAW Team Performance Index (ATPI).¹²

5. Team Communication and Coordination

Observers used matrices to tally communications rates during the scenarios. These quantitative measures were to be used to assess any reduction in the requirement for information exchange as a result of the training intervention. (Entin, 1994) In theory, members should now be more apt to anticipate communications needs and therefore pass pertinent information before it is requested.

G. INSTRUMENTATION

Samples of the various measuring instruments are provided in Appendix A.

H. TESTING AND PILOT TRIALS

A series of preliminary tests were conducted prior to the TACT experiment. Those tests looked at the performance measurement instruments, the stress evaluation methodology, and the performance of the DEFTT laboratory itself. An initial test of the performance measures, using instructors at the Aegis Training Unit, Moorestown, NJ, revealed that the scales were useable and that they appeared to be able to

¹² ATPI is a team outcome measure. It is scored on a scale from 1 to 7, and is based on the frequency of effective and ineffective behaviors exhibited by the AAW team. ATPI has demonstrated a sensitivity for detecting performance differences due to the presence of stress. (Malecki and Collyer, 1992)

distinguish between levels of performance. A preliminary stress evaluation methodology was developed, which uses a stress matrix, to evaluate stress levels within the baseline scenarios. The matrix became a tool to measure the number of targets (workload) versus the information available about the target (ambiguity level). Other testing and pilot studies were done on the DEFTT lab to ensure that it is capable of: recording time-stamped multiplexed channel data; supporting workstation simulation at both operator and command levels; and supporting networked simulation for simultaneously testing of multi-operator teams. In addition, the DEFTT scenarios were reviewed by experts to evaluate their "stressfulness" and to develop relevant background materials (i.e., geopolitical, ROE, order of battle) to be used during the experiment. (Malecki and Collyer, 1992)

Other experiments, which have preceded TACT, provided key findings which were further examined during the TACT experiment. Among those prior experiments were the SAINT experiment and the CHIPS experiment. The SAINT experiment studied the effects of team leader feedback on the situation assessment process in AAW teams (Gough, 1992), while CHIPS attempted to assess the impact of human cognitive limitations on team performance (Armbruster, 1993). The preceding TADMUS program experiments yielded results which supported TACT hypotheses and/or required further evaluation during the TACT experiment.

III. DATA DESCRIPTION

The TACT experiment collected both quantitative and qualitative data for analysis. Data collection instruments included pre and post-mission questionnaires, the NASA TLX workload index, observer rating forms, and team communication recording forms. The various collection instruments are included in Appendix A. Additionally, a videotape recording of the proceedings was made to support later analysis.¹³

A. EXAMPLE OF RAW DATA

Raw qualitative data was recorded by trained observers using the Teamwork and Performance: Observer's Rating Form. For each observation, an interval marking scale from one to seven was provided. The forms provided brief descriptions of the behaviors that should be observed for the lowest ratings on the scale and brief descriptions of the behaviors that should be observed and associated with the highest ratings on the scale. Using the descriptors as guides, the observers then rated each team's performance in the area of interest.

The author uses the data obtained from the rating forms to support all analysis for this thesis. A brief discussion of

¹³ The videotape equipment was used to record the multi-channel communications (both internal and external) and the TAO's tactical presentation as seen on the command and decision geographic situation summary or large screen display.

the uses of the pre and post-mission questionnaires, the TLX workload index, and the team communication recording forms are presented in the following text in order to provide a more complete picture of the experiment.

1. Pre and Post-mission questionnaires--these forms provided scales ranging from one to seven for subjects to annotate their feelings regarding their confidence in the teams' and their own abilities to complete the assigned tasking and to ascertain if the subjects felt they were able to assist others. These questionnaires were designed to support testing of the shared mental model theories presented in Chapter I.

2. TLX workload index--these forms provided a scale for test subjects to rate the previously completed missions in terms of the following six areas: mental demand, physical demand, temporal (time pressure) demand, performance, effort, and frustration.

3. CIC Team Communication Recording Forms--the TAO's communications and those of the team members were recorded by observers using simple tick marks to note each occurrence in a matrix format. The matrix data will support analysis of communications rates and the nature of the communications in terms of them being requests, transfers or acknowledgements.

All of the data collected and described above will be used by Alphatech, INC. in their analysis. Additional data analysis, not discussed here, will be conducted by the Naval Training Systems Center and by the Naval Command, Control and Ocean Surveillance Center (NCCOSC) RDT&E Division as they also review the TACT experiment.

B. DATA PROBLEMS

No data collection or interpretation problems were encountered relevant to this analysis.

C. DATA TABLE CODING SCHEME

Each observer's scores were recorded on the rating forms. Those values, plus specific identification and experiment control variables were transcribed into a data table of 34 columns of variables by 48 rows of iterations. (See Appendix B.) The first seven columns consist of identification and experiment control variables. Of the remaining 27 columns, the first 15 correlate to the teamwork measures of the rating form. The next eight columns measure team performance in general and the final four columns are associated with performance specific to the particular scenario. The coding scheme for the first seven columns is presented in Table II. The remainder of the columnar values are transcribed directly from Appendix B.

D. DATA REDUCTION

The first step in data reduction was to sort the data spreadsheet by groupings which would support analysis of the hypotheses in question. After sorting the data, averages were computed for performance and teamwork scores using the ATP1 and ATOM measures discussed in Chapter II. Row averages for all of the data entries were then extracted along with their associated identifiers. After reducing and arranging the initial spreadsheet into a more manageable format, further

Table II: DATA CODING SCHEME

| COLUMN | VARIABLE | IDENTIFIER |
|--------|------------------------|---|
| A | Site ID | 1 = SWOS Newport; 2 = NPS Monterey |
| B | Experimental Condition | 1 = Control; 2 = TACT; 3 = TACT + |
| C | Team ID | One through six |
| D | Observation | 1 = Pretraining; 2 = Posttraining |
| E | Scenario # | One or two |
| F | Stress Level | 1 = Low; 2 = High |
| G | Trial # | One through four |

subdivisions of columns were completed as required to support a detailed categorical analysis of the experimental data. The modified data spreadsheet is provided in Appendix B.

IV. ANALYSIS

This chapter describes the analysis procedures used for the TACT experiment. It sets forth the analysis plan and then provides the detailed steps that were conducted during the process. In the final section of the chapter, the detailed results of the experiment are presented.

A. ANALYSIS PLAN

The analysis of experimental results was conducted in two phases. First, the ATPI outcome measures were used to rate team performance effectiveness, then the ATOM process measures were used to evaluate teamwork behaviors. Using the data collected from the observer's rating forms, the experiment attempts to detect differences in team performance and teamwork evaluation scores where it is expected that some experimental treatments will be more effective than others. Based on the findings, the two null hypotheses presented in Chapter II will be rejected if the sample evidence contradicts them and provides strong support for the alternative hypotheses.

The statistical analysis of the test data was completed with the aid of Minitab. Minitab generates a p-value that indicates the probability of observing an outcome like the one actually observed or more unusual, under the assumption that

the given dependent variable is effected the same by all levels of the independent variables (when the null hypothesis is true). Tests of significance at $\alpha = 0.05$ will be used as rejection criteria for the null hypotheses. Using Minitab, when the p-value is less than the critical value ($\alpha = 0.05$) one can be 95% certain that any change in the dependent variable was caused by a change in the independent variable (treatment condition), not a random occurrence.¹⁴

B. METHODOLOGY

The recommended analysis for "Design 4" is based on gain score, using the analysis of covariance (ANCOVA) tests (Campbell and Stanley, 1965). In addition to these tests, normality and scatter plots are used to provide additional insight during the analysis process. For each hypothesis, an initial ANCOVA test is run on the data. The posttraining intervention test score is used as the dependent variable and the pretraining intervention test score as the covariate. The gain scores were then determined by comparing pretraining and posttraining scores amongst all test groups. Using the gain

¹⁴ The significance level α represents the probability of rejecting the null hypothesis when the null hypothesis is true. Using Minitab, if the p-value is less than α the null hypothesis is rejected.

scores, a second ANCOVA test is then conducted with pretraining scores being used as the covariate.¹⁵

C. RESULTS

1. Hypothesis One: Test of Performance Measures

The ANCOVA test indicates that the covariate, pretraining score, has a highly significant effect on the post performance score ($p\text{-value} = 0.002$). Additionally, the test indicates that one of the experimental factors in question (level of training) does indeed apparently account for a statistical difference in the posttraining performance scores of the teams ($p\text{-value} = 0.011$). There is no indication that the other independent variable (level of stress) significantly effects the performance scores across the experimental conditions. The Minitab printout is provided in Table III.

Graphical representations of the pretraining and posttraining mean performance scores were examined for the three experimental conditions at the two levels of stress. These two bar graphs when examined together show that the control groups high and low stress performance was essentially unchanged throughout the experiment. At the other two levels of treatment, mean performance scores increased for both stress conditions. The observer is left to conclude that the

¹⁵ The covariate is an uncontrolled experimental variable that influences the response but is itself unaffected by experimental factors. Using the ANCOVA technique, adjustments are made for the covariates effect on the dependent variable.

Table III: ANCOVA FOR POSTTRAINING PERFORMANCE SCORES

```

MTB > ANCOVA 'postperf' = cond24 stress24;
SUBC> Covariates 'preperf'.
Factor      Levels Values
cond24       3         1      2      3
stress24     2         1      2

```

Analysis of Covariance for postperf

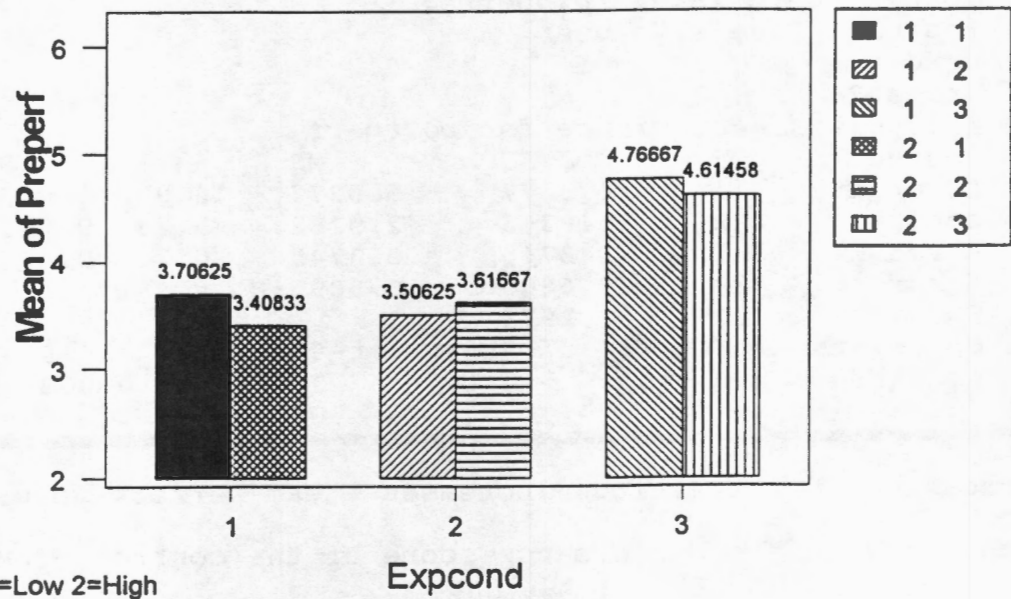
| Source | DF | ADJ SS | MS | F | P |
|------------|----|---------|--------|-------|-------|
| Covariates | 1 | 6.5377 | 6.5377 | 12.83 | 0.002 |
| cond24 | 2 | 5.8363 | 2.9182 | 5.73 | 0.011 |
| stress24 | 1 | 0.3745 | 0.3745 | 0.74 | 0.402 |
| Error | 19 | 9.6808 | 0.5095 | | |
| Total | 23 | 32.2971 | | | |

| Covariate | Coeff | Stdev | t-value | P |
|-----------|--------|-------|---------|-------|
| preperf | 0.5436 | 0.152 | 3.582 | 0.002 |

presence of training increases team effectiveness when compared to the performance score of the control group. See Figure 1 to compare the pre and posttraining scores by the three conditions and levels of stress.

Examination of the scatter plot of the posttraining versus the pretraining performance scores confirmed some additional expectations. From the ANCOVA test, the positive covariate coefficient predicted that low pretraining performance scores were an indicator of low posttraining performance scores and that a high pretraining score should be followed by a high posttraining score. For the most part this was the case. The plot also confirmed (as expected) little or no movement for about half of the control groups scores while dramatic improvement was shown for two of eight of the test scenarios where groups received tact only training. The plot

Pretraining Performance by Condition and Stress



Posttraining Performance by Condition and Stress

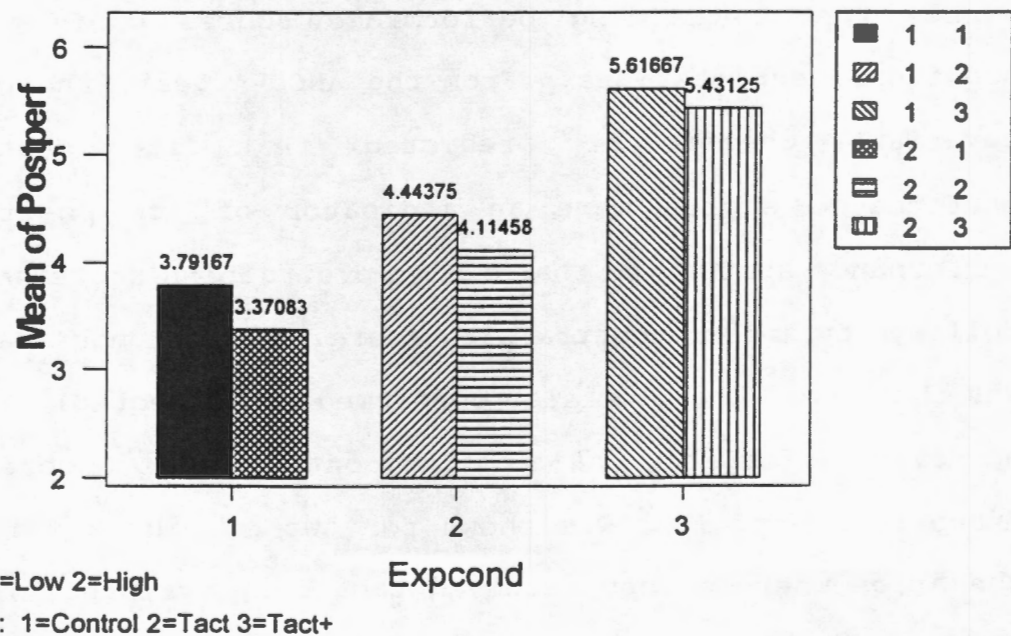


Figure 1: Pretraining and Posttraining Performance Scores

also shows that the tact plus groups happened to be strong performers prior to receiving the intervention training. See Figure 2.

The ANCOVA test using the performance gain score as the dependent variable and the pretraining performance score as the covariate also indicates that the level of training is responsible for differences in performance scores (p-value = 0.011). Again stress does not show as a significant factor, while the covariate is again determined to be a highly significant factor in the analysis. The Minitab printout is provided in Table IV.

Table IV: ANCOVA FOR PERFORMANCE GAIN SCORES

```

MTB > ANCOVA 'perfgain' = cond24 stress24;
SUBC> Covariates 'preperf'.
Factor    Levels Values
cond24      3      1      2      3
stress24    2      1      2
Analysis of Covariance for perfgain
Source      DF      ADJ SS      MS      F      P
Covariates   1      4.6096      4.6096      9.05  0.007
cond24       2      5.8363      2.9182      5.73  0.011
stress24     1      0.3745      0.3745      0.74  0.402
Error       19      9.6808      0.5095
Total       23     17.5931
Covariate    Coeff      Stdev    t-value      P
preperf     -0.4564      0.152     -3.008      0.007

```

A plot of the performance gain scores versus experimental conditions and stress is also insightful. See Figure 3. When the graph is partitioned to show the effects of high and low stress, it indicates a relatively dramatic

Scatter Plot of Post vs Pretraining Performance Scores

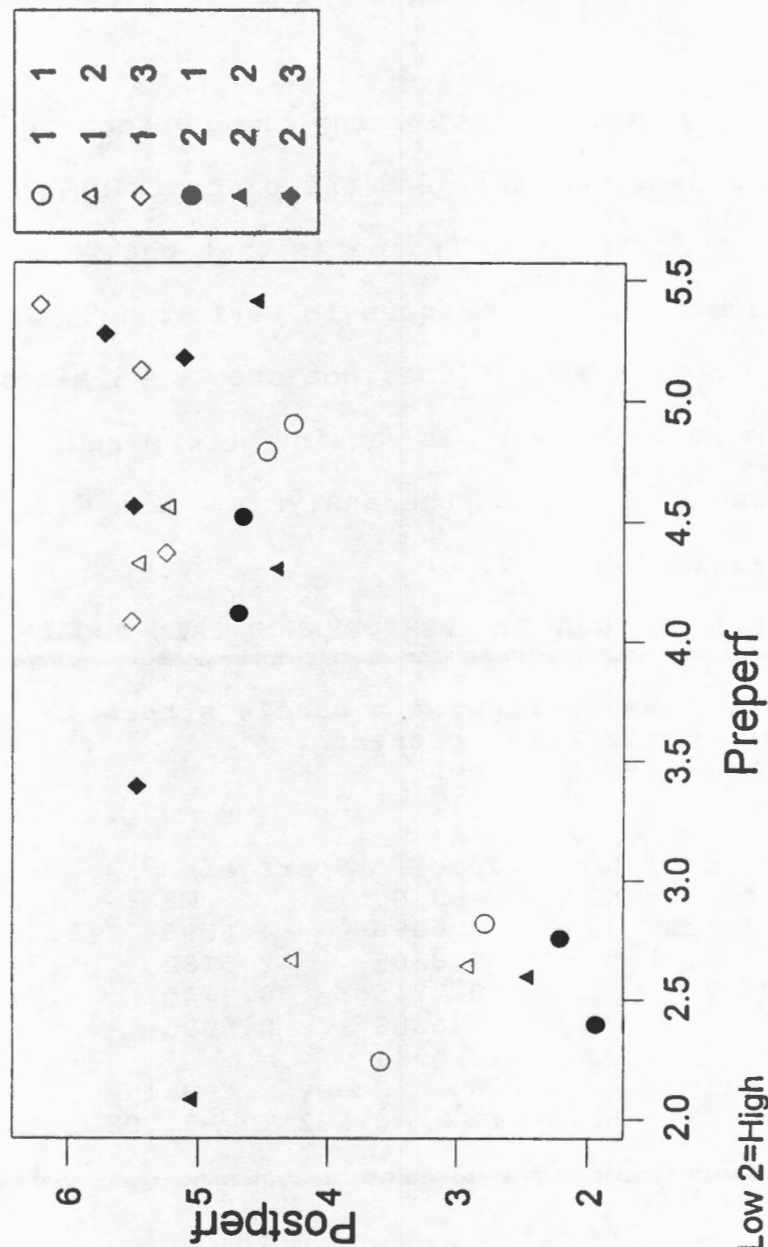


Figure 2: Scatter Plot of Posttraining vs. Pretraining Performance Scores

Performance Gain by Condition and Stress

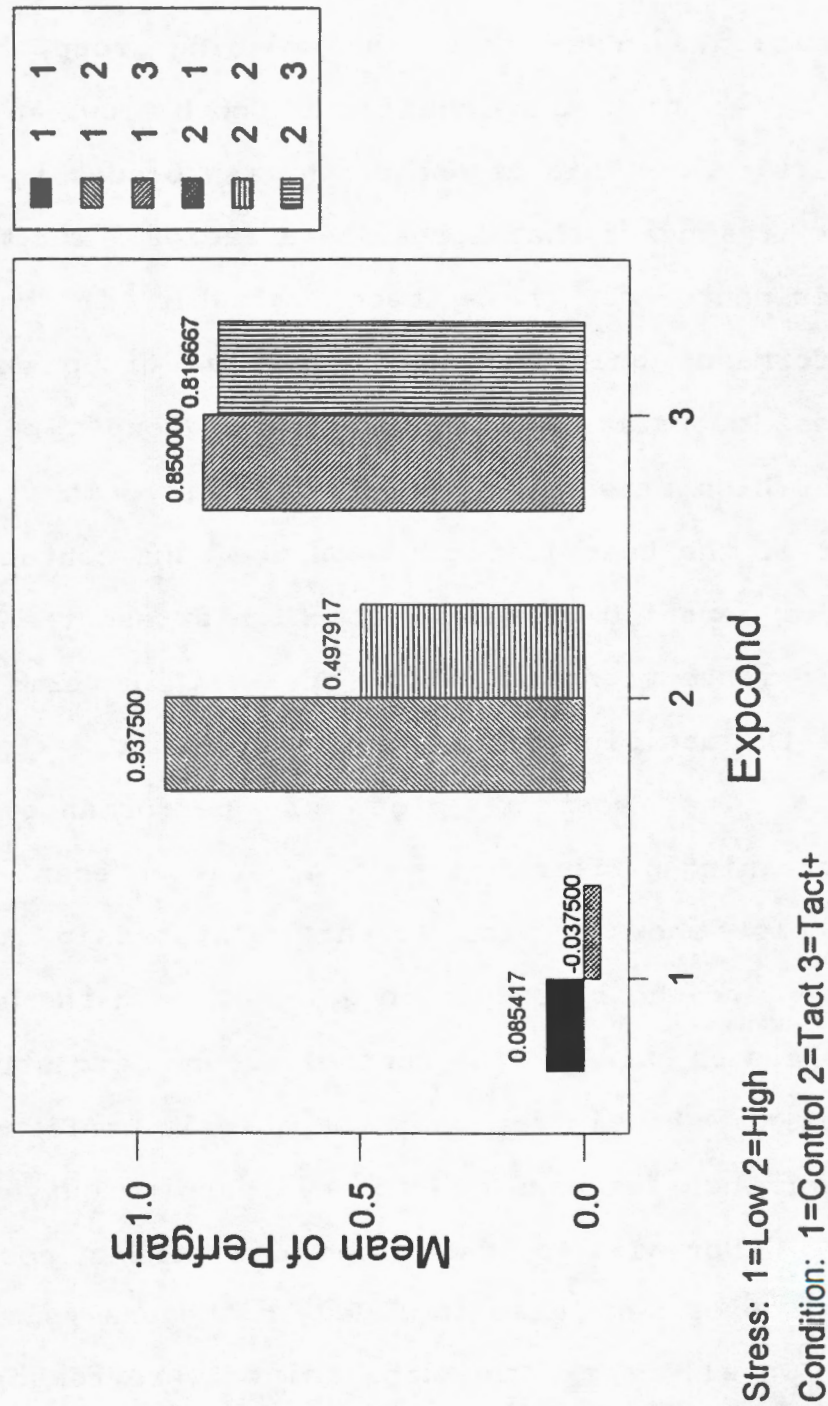


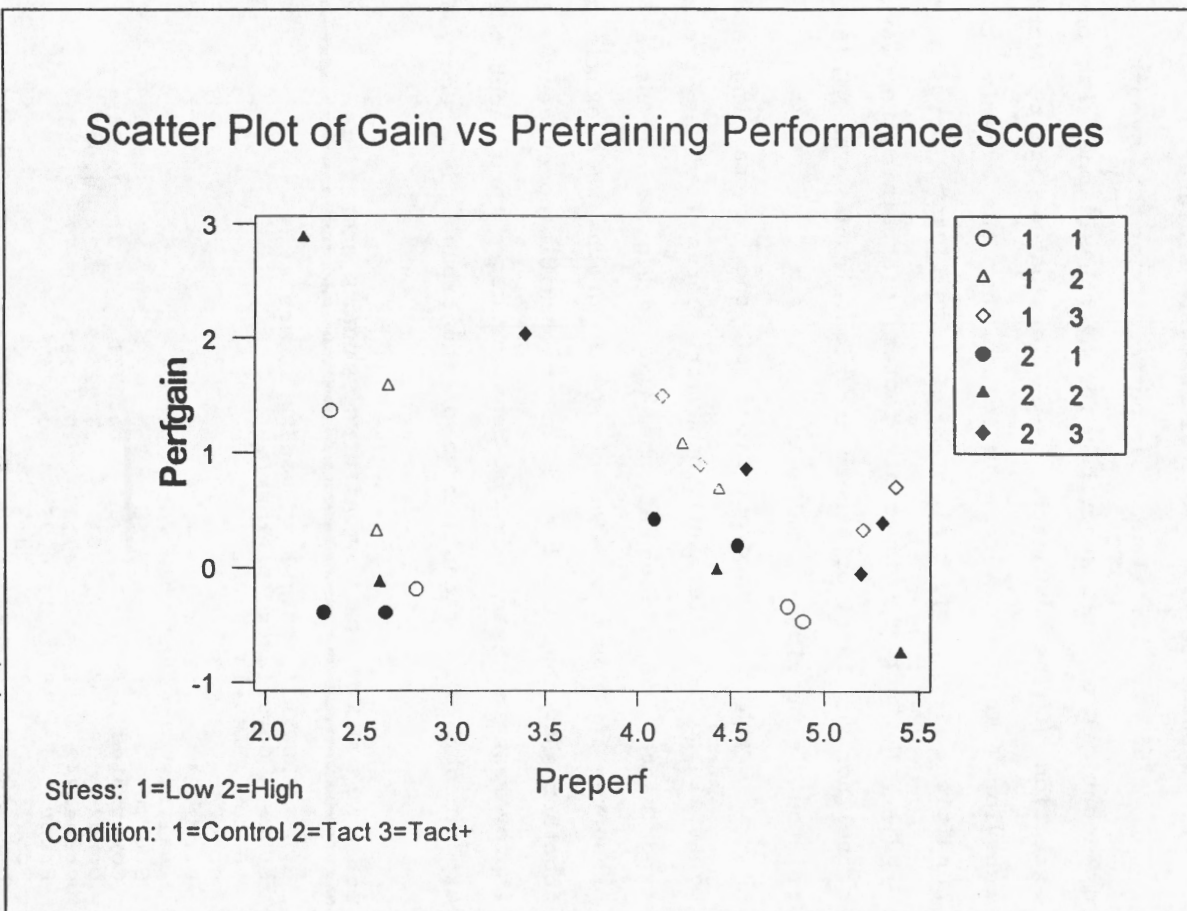
Figure 3: Performance Gain Scores by Experimental Conditions and Levels of Stress

increase in the low stress performance for the tact group and a lesser increase in performance under the high stress condition. In the tact plus training group, the performance gain was high and equal for both low and high stress conditions. This is one of the few places in the experiment that it appears that stress is a factor. The TAO's situation assessments may have been valuable in maintaining the performance gain for the tact plus group during the high stress scenarios whereas the tact group's performance gain under high stress was not as dramatic. It stands to reason that if the team is focused on the same contacts of interest during a period of relatively high stress then their overall performance might be better at least in terms of addressing what the decision maker sees as critical.

The scatter plot of performance gain versus pretraining performance score is also presented in Figure 4. The plot shows a weak linear relationship for pretraining scores and their associated gains. Again the high performers had less to gain and the control groups demonstrated little or no gain. This is important because it confirms little or no performance increase due to any learning curve effect.

Normality plots for the pretraining, posttraining, and gain scores were also included in the analysis (see Appendix C). In all cases, the data points were reasonably close to normal. The assumption of normality for the data set was required for the above tests to maintain their validity.

Figure 4: Scatter Plot of Gain vs. Pretraining Performance Scores



2. Hypothesis Two: Test of Teamwork Measures

The statistical analysis performed for this hypothesis is identical to that described for hypothesis one with one exception. The parameter being evaluated is teamwork behavior. The ANCOVA test indicates that the experimental condition (level of training) is significant (p-value = 0.008). Neither the covariate factor (pretraining teamwork score) nor the level of stress are significant. The Minitab printout is provided in Table V.

Graphical representations of the pretraining and posttraining mean teamwork behavior scores for the three experimental conditions at the two levels of stress are presented in Figure 5. These two bar graphs when examined together show that the control groups exhibit no evidence of improvement in their teamwork behavior score throughout the experiment. In contrast, both of the groups that received

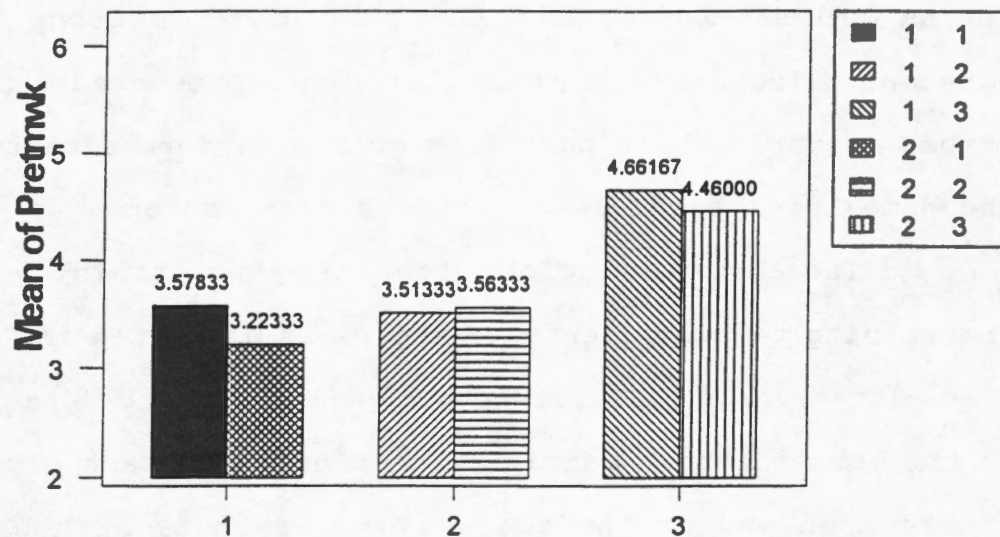
Table V: ANCOVA FOR POSTTRAINING TEAMWORK SCORES

```

MTB > ANCOVA 'posttmwk' = cond24 stress24;
SUBC> Covariates 'pretmwk'.
Factor      Levels Values
cond24       3         1     2     3
stress24     2         1     2
Analysis of Covariance for posttmwk
Source      DF      ADJ SS      MS      F      P
Covariates   1      1.2731      1.2731    2.07  0.166
cond24       2      7.8512      3.9256    6.39  0.008
stress24     1      0.4713      0.4713    0.77  0.392
Error       19     11.6799      0.6147
Total       23     28.1317
Covariate    Coeff      Stdev    t-value      P
pretmwk      0.2605      0.181      1.439      0.166

```

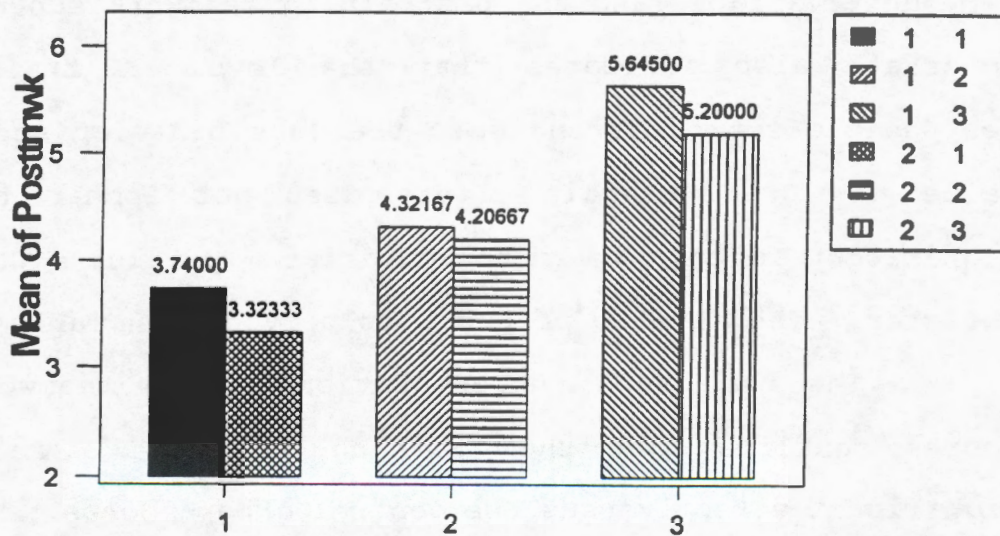
Pretraining Teamwork by Condition and Stress



Stress: 1=Low 2=High

Condition: 1=Control 2=Tact 3=Tact+

Posttraining Teamwork by Condition and Stress



Stress: 1=Low 2=High

Condition: 1=Control 2=Tact 3=Tact+

Figure 5: Pretraining and Posttraining Teamwork Behavior Scores

training show positive movement. There is no substantial graphical evidence that scores are influenced by the level of stress unless one argues that the control group shows a substantial decrease in their score when presented with a high stress scenario while the other groups perform essentially at the same level regardless of the stress factor.

The scatter plot for the posttraining versus pretraining teamwork behavior scores is presented in Figure 6. This plot reveals a dispersed grouping of control group scores on the low end and a fairly tight cluster of tact plus scores on the high end of the scale. The graph also shows a fair linear relationship of increasing scores as the level of training increases for each of the test conditions.

The ANCOVA test using the teamwork gain score as the dependent variable and the pretraining teamwork score as the covariate also indicates that the level of training is responsible for differences in teamwork behavior scores (p -value = 0.008). Again stress does not appear to be a significant factor, while the covariate (p -value = 0.001) is a factor. The Minitab printout is provided in Table VI.

The bar graph representation of the teamwork gain scores confirms that the training did have a relatively significant effect versus the control group scores. However, across the levels of stress, there appears to be no difference in the relative gains. The bar graph is presented in Figure 7.

Table VI: ANCOVA FOR TEAMWORK GAIN SCORES

```

MTB > ANCOVA 'tmwkgain' = cond24 stress24;
SUBC> Covariates 'pretmwk'.
Factor      Levels Values
cond24       3         1         2         3
stress24     2         1         2

```

Analysis of Covariance for tmwkgain

| Source | DF | ADJ SS | MS | F | P |
|------------|----|---------|---------|-------|-------|
| Covariates | 1 | 10.2566 | 10.2566 | 16.68 | 0.001 |
| cond24 | 2 | 7.8512 | 3.9256 | 6.39 | 0.008 |
| stress24 | 1 | 0.4713 | 0.4713 | 0.77 | 0.392 |
| Error | 19 | 11.6799 | 0.6147 | | |
| Total | 23 | 24.5014 | | | |

In the next graphical analysis, a scatter plot of gain versus pretraining teamwork behavior score is presented in Figure 8. The plot shows a negative linear relationship for pretraining scores and their associated gains. Again the high pretraining performance means less room for gain. As with the performance measures, normality plots for the pretraining, posttraining, and gain scores were conducted. The data points were determined to be reasonably close to normal. As with the performance measures of the first hypothesis, the assumption of normality for the data was required for the ANCOVA tests to maintain their validity. The normality plots are provided in Appendix C.

3. An Additional Observation

The previous data analysis focused on performance and teamwork observation scores as dependent variables with experimental condition and level of stress being the

Scatter Plot of Post vs Pretraining Teamwork Scores

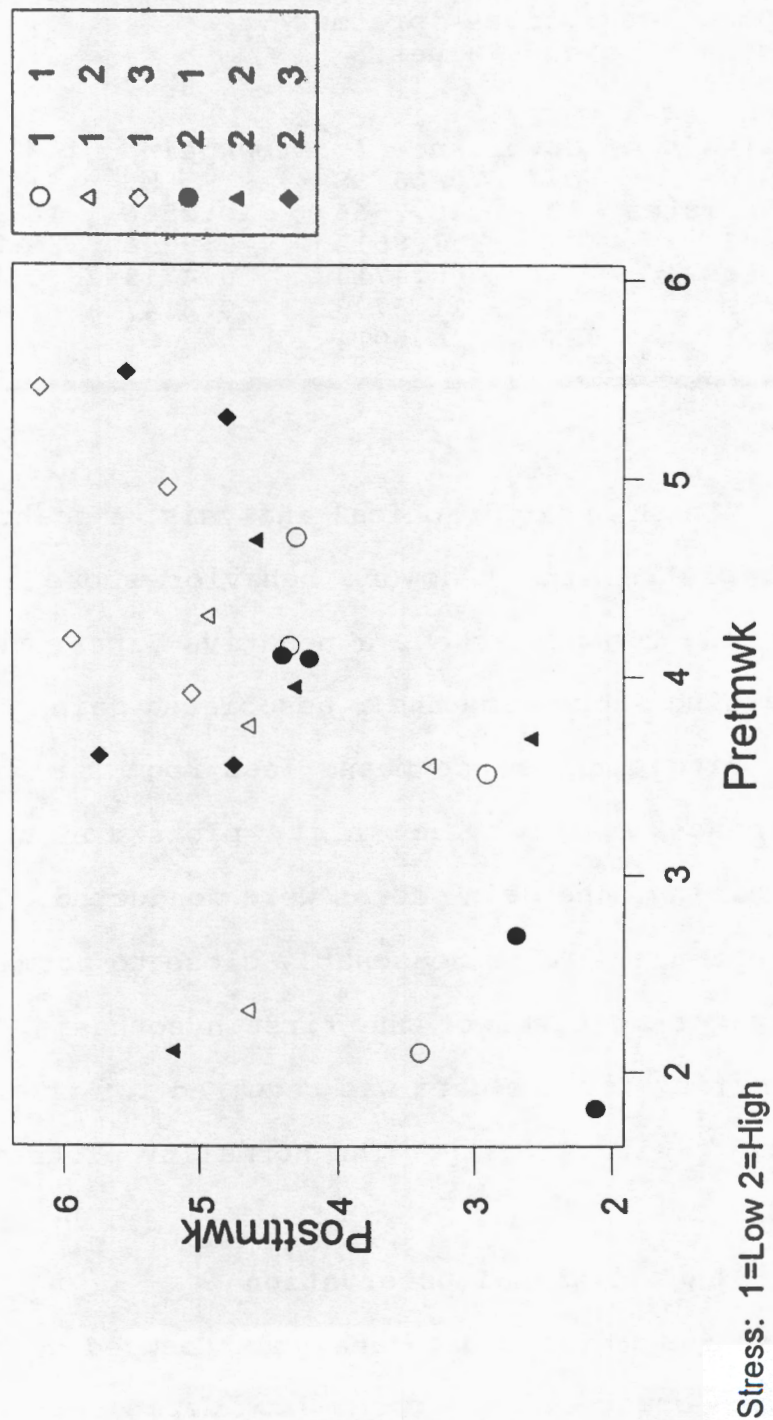


Figure 6: Scatter Plot of Posttraining vs. Pretraining Teamwork Behavior Scores

Teamwork Gain by Condition and Stress

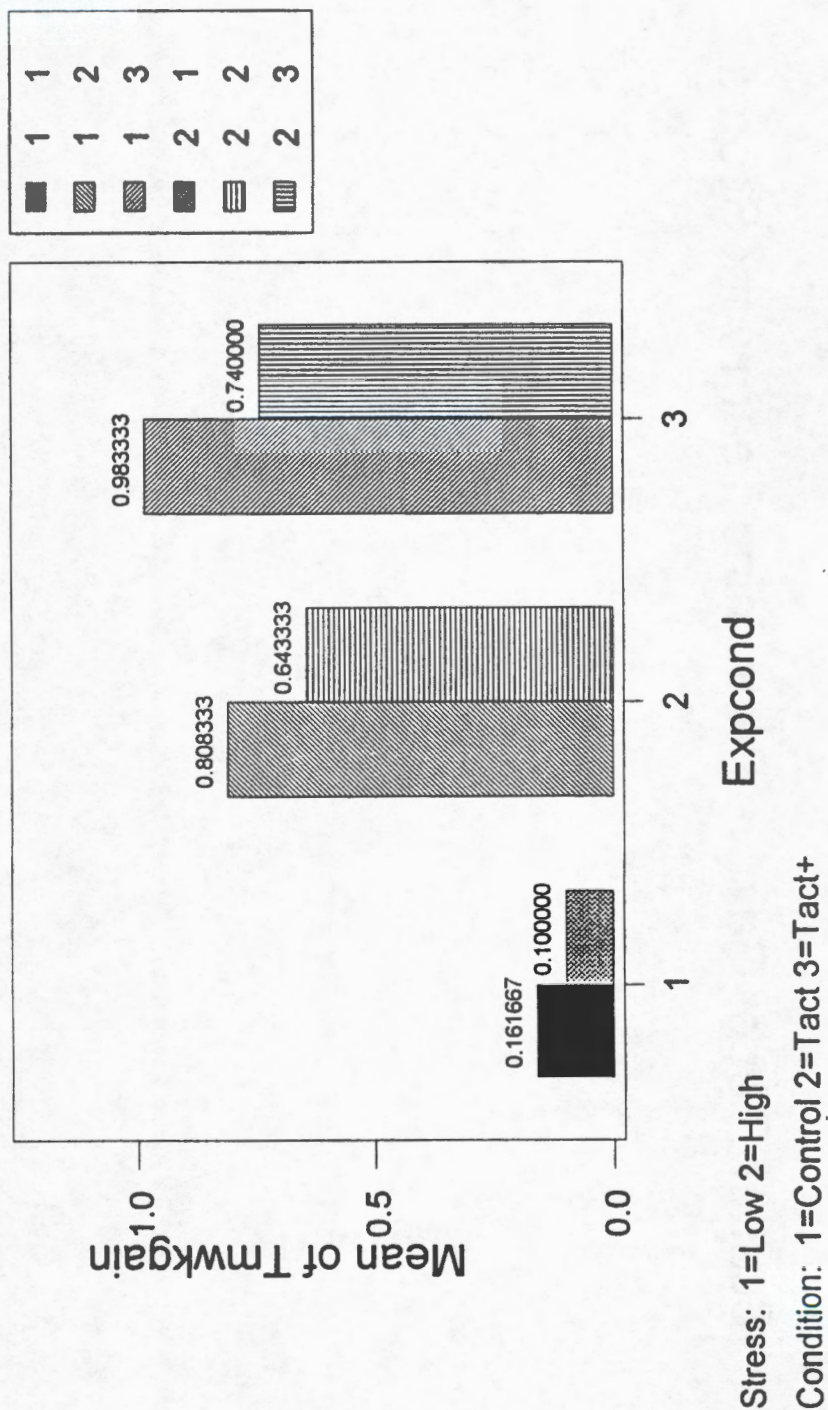


Figure 7: Teamwork Behavior Gain Scores by Experimental Conditions and Levels of Stress

Scatter Plot of Gain vs Pretraining Teamwork Scores

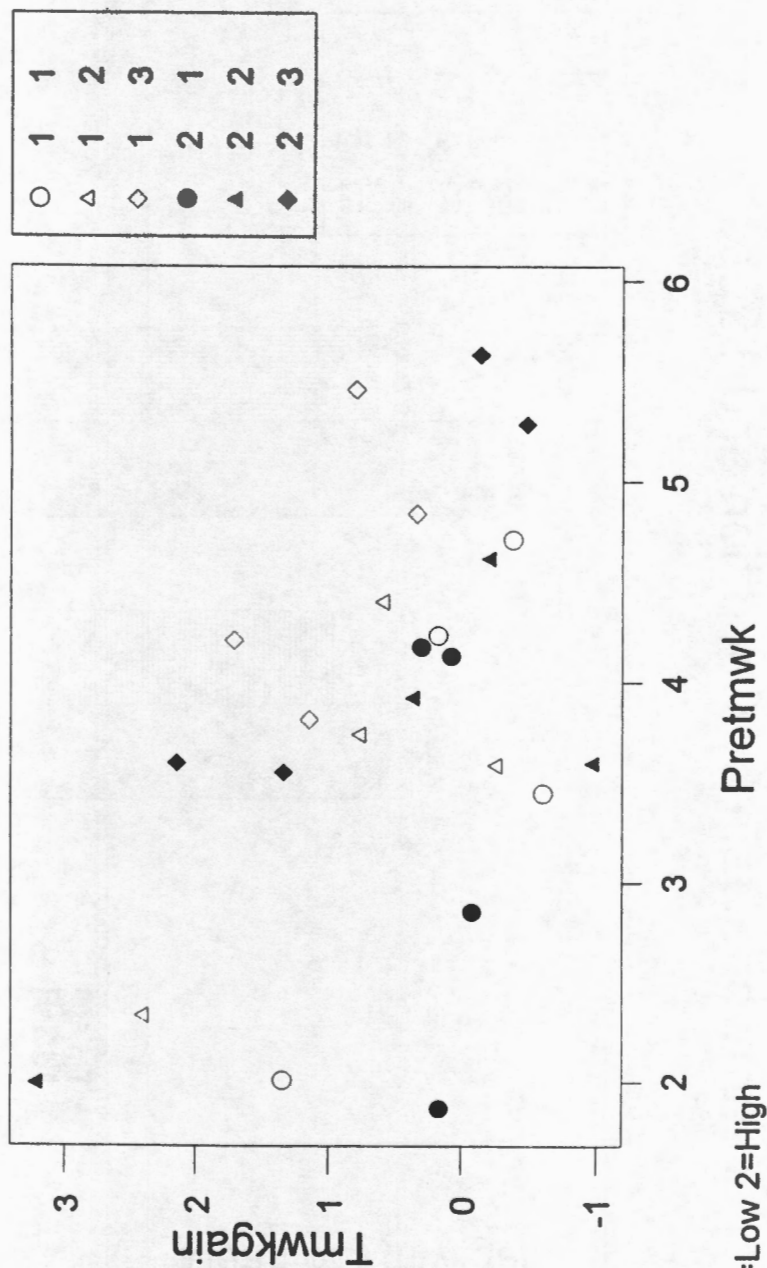


Figure 8: Scatter Plot of Gain vs. Pretraining Teamwork Behavior Scores

independent variables. During the course of the analysis, the data was also checked for differences in team scores between the two sites. If significant differences in site scores were noted, then concerns would be raised regarding the validity of the experimental results due to possible biases being introduced as a result of two different sets of observers being used between the two test sites.¹⁶

The following group of illustrations (Figures 9-14) graphically show the dispersions in scoring patterns between the sites. In scatter plots, the NPS subjects tended to be homogeneously dispersed, while the SWOS subjects were interspersed toward either end of the scoring spectrum (control and tact groups rated near the low end of the scale; tact plus groups rated near the high end of the scale both before and after training). Though the scoring between the sites was noted as peculiar, it was felt that the prior analysis was not compromised.¹⁷ When viewed separately, the posttraining scoring from SWOS seems to show more dramatic effects of the training intervention, across the levels. On

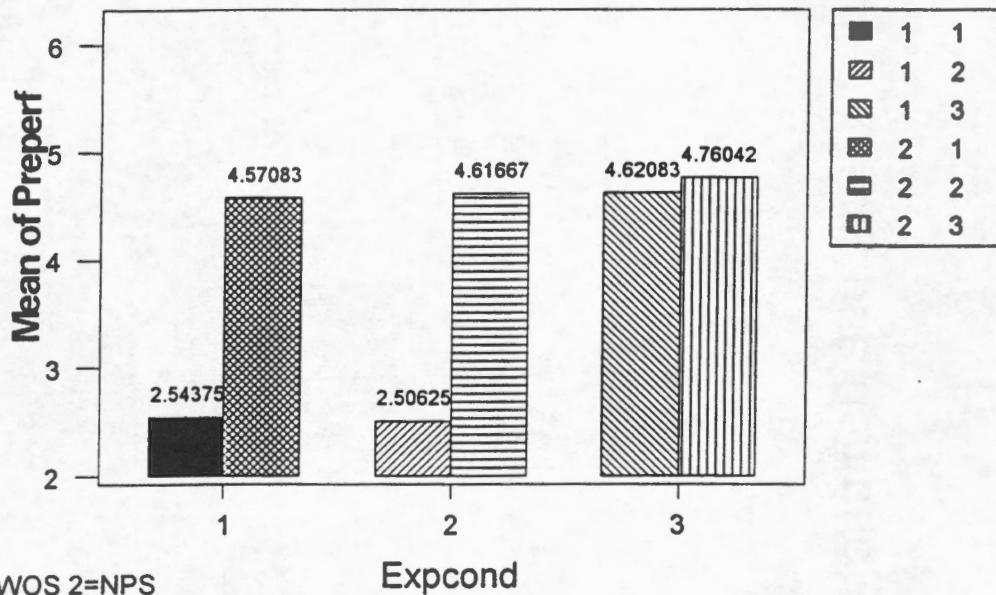
¹⁶ To preclude against biased observations, it is suggested that the same observers be used for all evaluations and that they be kept ignorant as to which test subjects received which treatments (Campbell and Stanley, 1965).

¹⁷ In reviewing the data, it was noted that quantitatively higher mean scores were given by the NPS observers. However, in focusing on the effectiveness of the intervention training techniques, it was judged that if all scores were averaged together then the effects of the quantitative differences would be negated. (Entin, 1994)

the other hand, the scoring at NPS showed more realistic near equal evaluations of team abilities prior to the teams being exposed to training. When the pretraining scores are also considered this difference is mostly mitigated. NPS data alone also showed improvements with increasing intervention, though less dramatic. There is no obvious explanation for this apparent anomaly in data between the two sites.¹⁸

¹⁸ As stated in Chapter I, this paper focuses on the experiment as observed from NPS. However, for an increased sample size, the author uses the data obtained from both experimental test sites during the analysis phase.

Pretraining Performance by Condition and Site



Posttraining Performance by Condition and Site

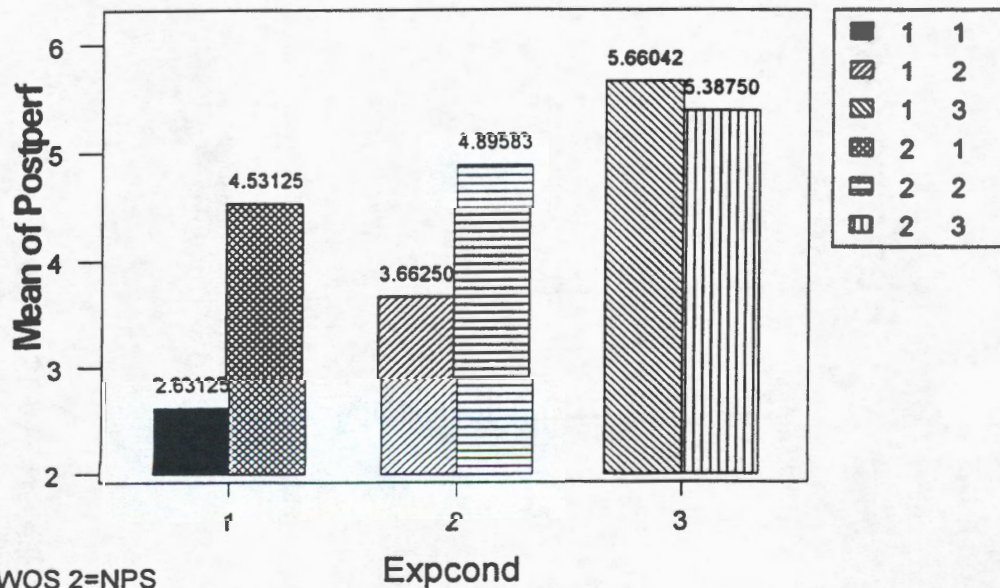


Figure 9: Pretraining and Posttraining Performance Scores

Performance Gain by Condition and Site

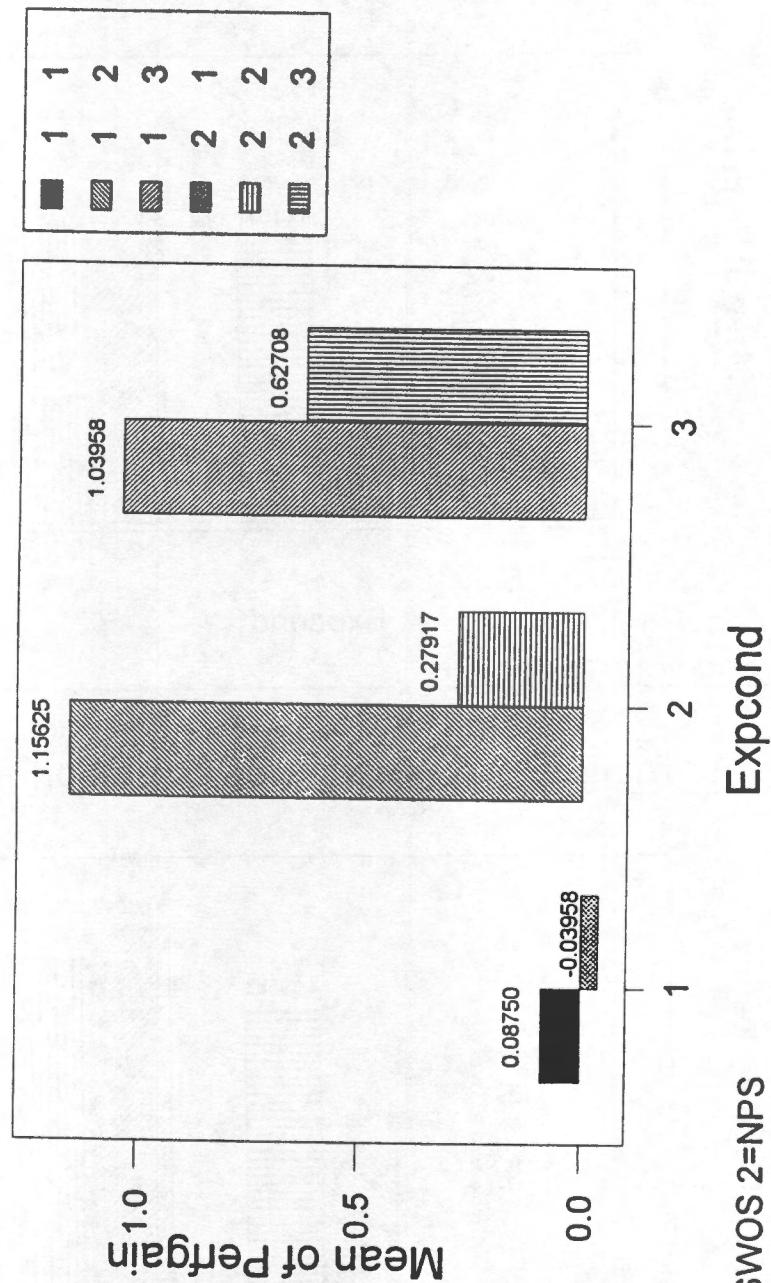
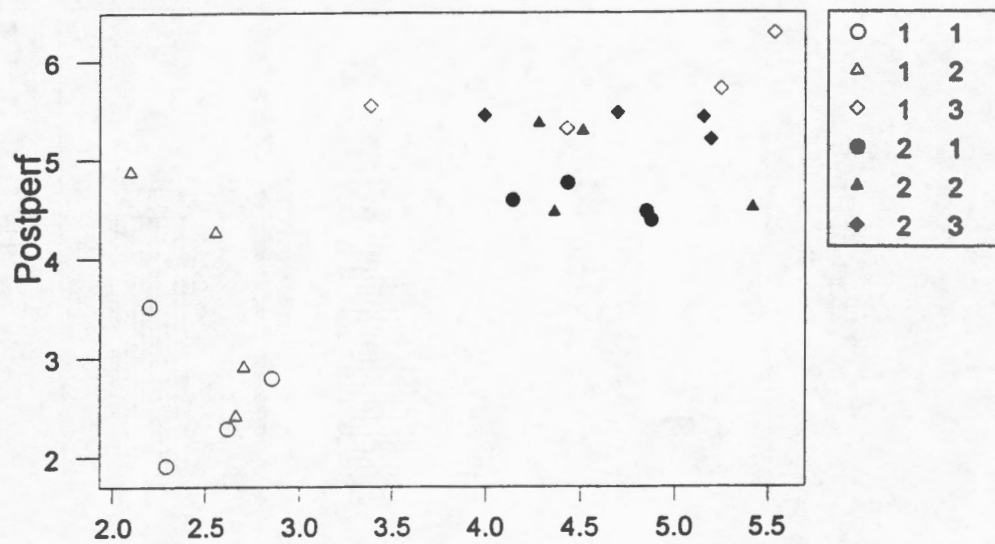


Figure 10: Performance Gain Scores by Experimental Conditions and Sites

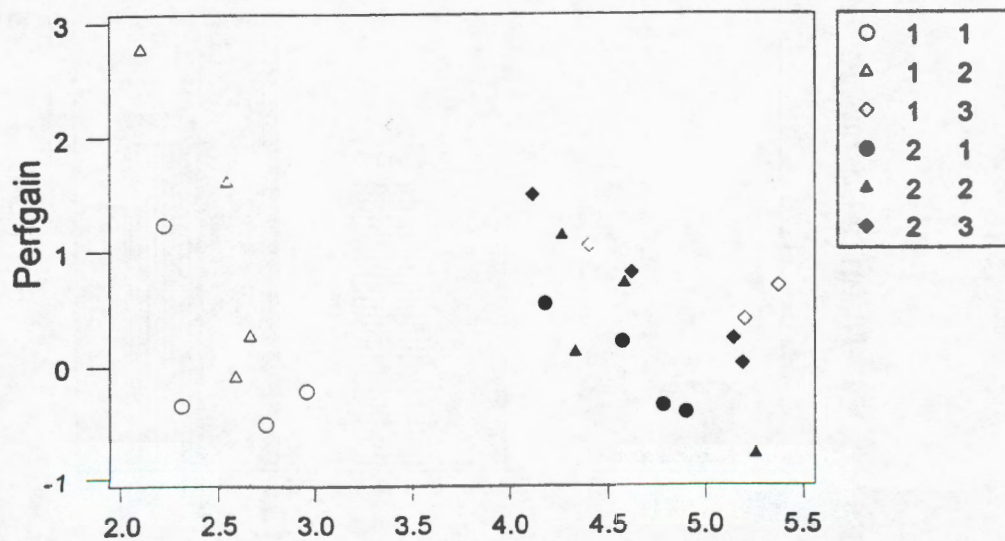
Scatter Plot of Post vs Pretraining Performance Scores



Site: 1=SWOS 2=NPS

Condition: 1=Control 2=Tact 3=Tact+

Scatter Plot of Gain vs Pretraining Performance Scores

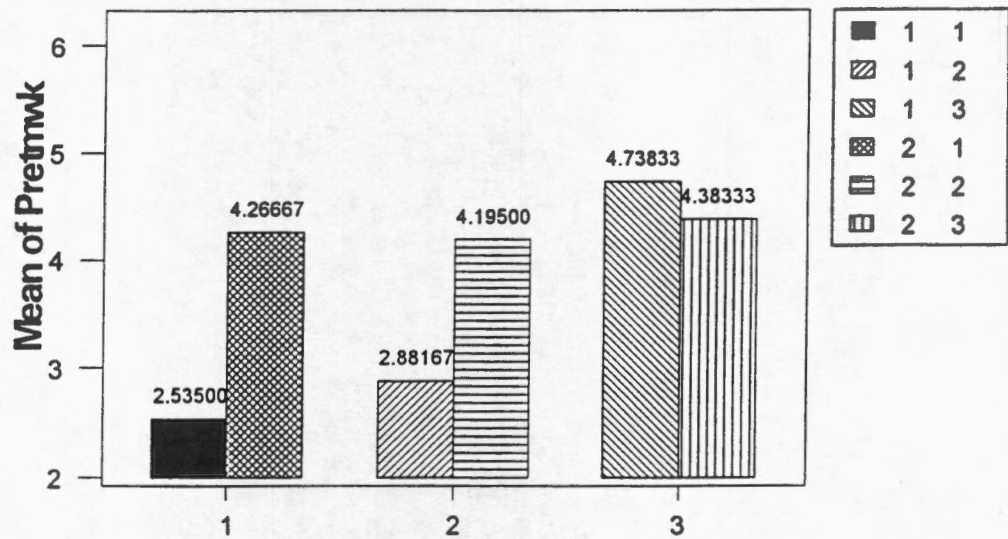


Site: 1=SWOS 2=NPS

Condition: 1=Control 2=Tact 3=Tact+

Figure 11: Scatter Plots of Performance Scores by Sites

Pretraining Teamwork by Condition and Site

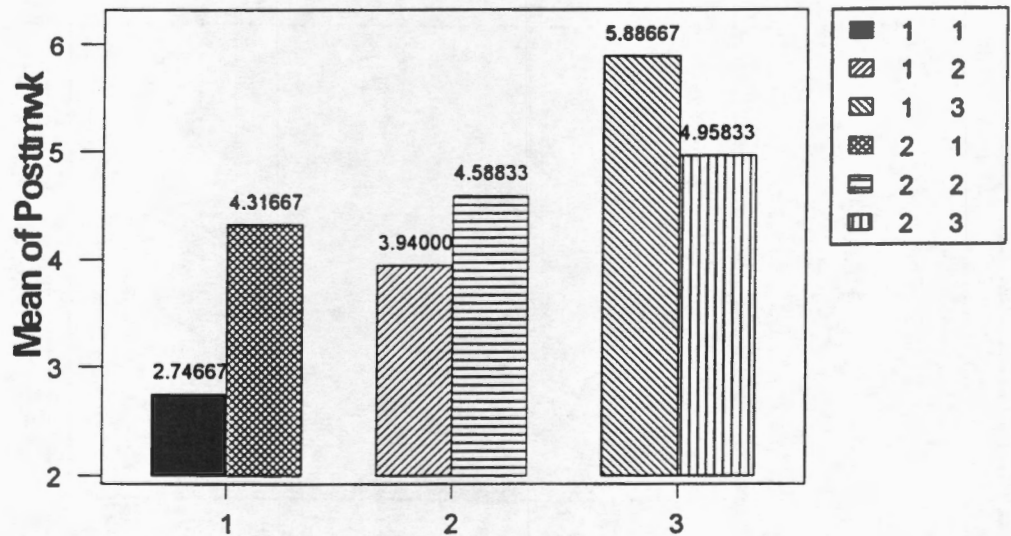


Site: 1=SWOS 2=NPS

Expcnd

Condition: 1=Control 2=Tact 3=Tact+

Posttraining Teamwork by Condition and Site



Site: 1=SWOS 2=NPS

Expcnd

Condition: 1=Control 2=Tact 3=Tact+

Figure 12: Pretraining and Posttraining Teamwork Behavior Scores

Teamwork Gain by Condition and Site

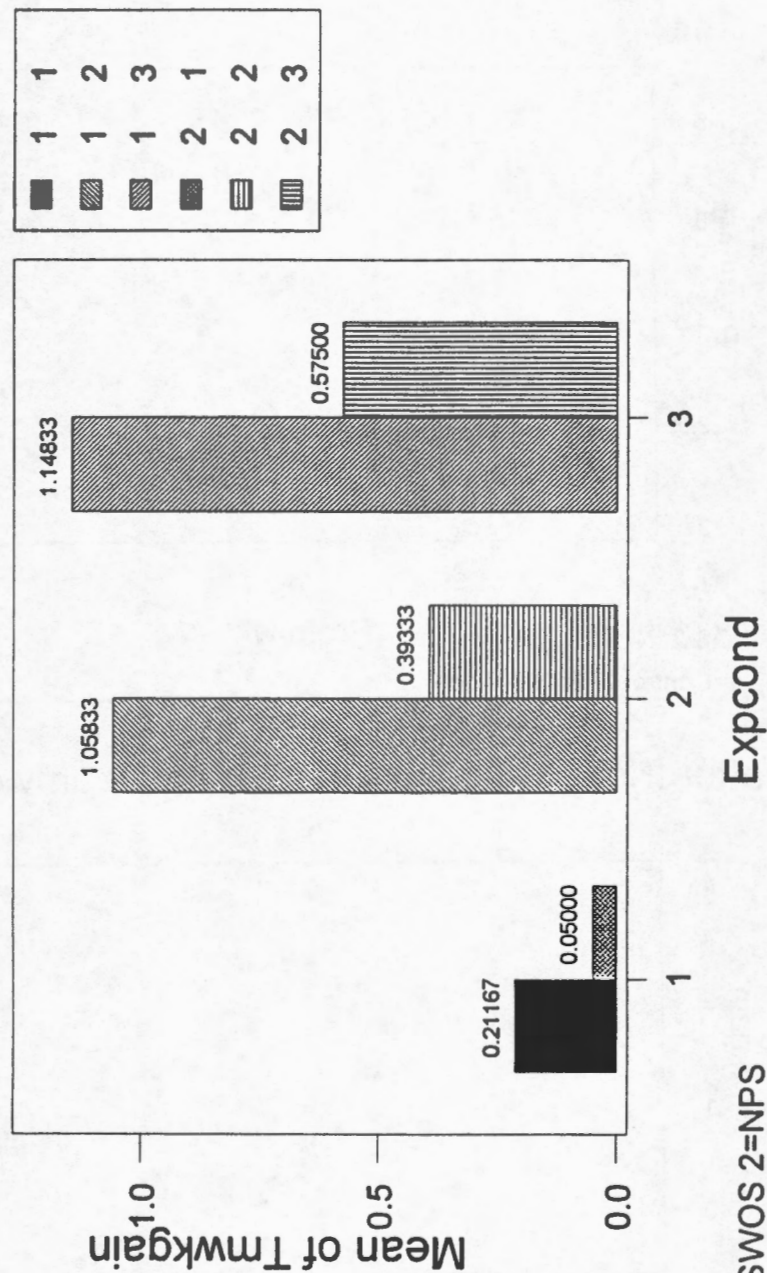
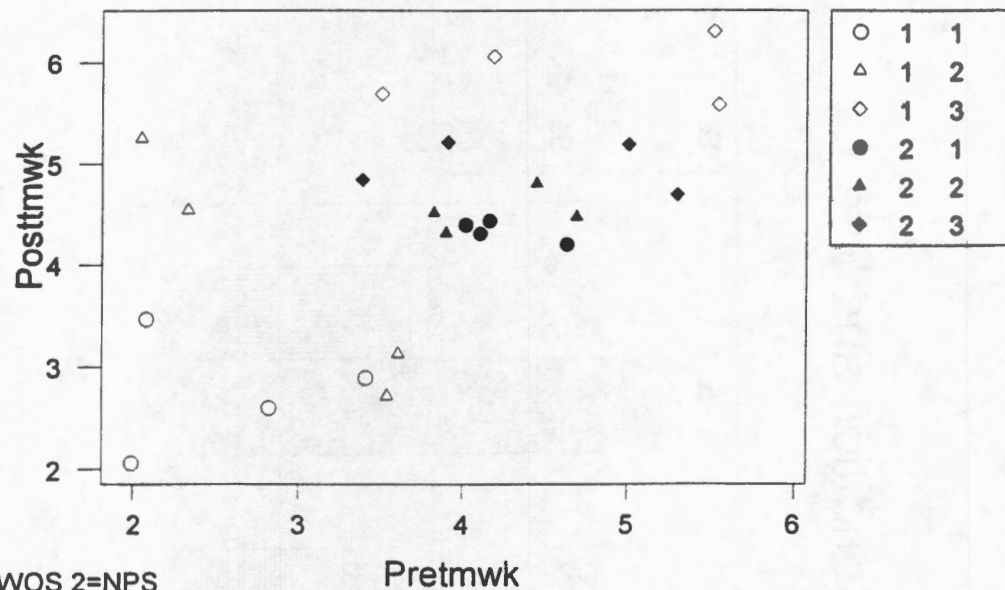


Figure 13: Teamwork Behavior Gain Scores by Experimental Conditions and Sites

Scatter Plot of Post vs Pretraining Teamwork Scores



Scatter Plot of Gain vs Pretraining Teamwork Scores

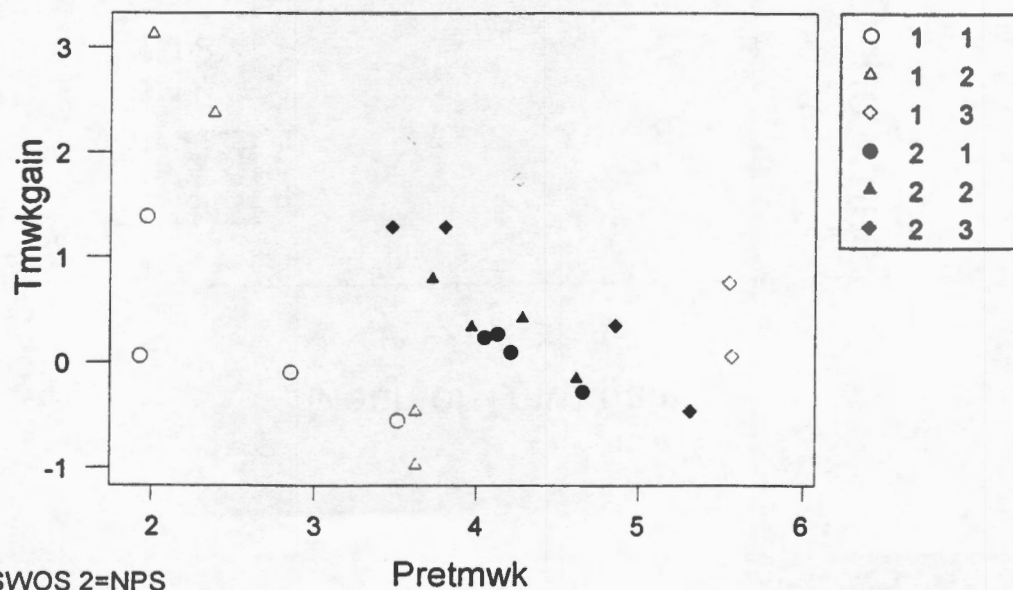


Figure 14: Scatter Plots of Teamwork Behavior Scores by Sites

V. CONCLUSIONS

The purpose of this chapter is to discuss the experimental results with regard to the two hypotheses presented in Chapter II and to revisit the initial research questions.

A. HYPOTHESES

Based upon the detailed analysis presented in Chapter IV, the two null hypotheses are rejected in favor of the alternate hypotheses. In both cases, data gathered during the course of the experiment supports the premise that adaptation and coordination training strategies, when implemented, have a measurable effect on a team's ability to perform under the test conditions presented during the course of this study. A summary table (i.e., Table VII) is presented to show the effectiveness of the training strategies across the experimental conditions for both of the hypotheses.

B. RESEARCH QUESTIONS

The primary research questions from Chapter II were:

1. If team members are taught to monitor other team members and offer assistance during periods of high stress (presence of heavy workload on a team member) will the teams overall level of performance improve?
2. If teams are given a technique to achieve a shared mental model of the current tactical picture, such as structured TAO situation assessments, would their performance level be improved?

Table VII: Pre-Posttraining Scoring Summary

| MEASURE | | Score: Mean (Standard Deviation) | | |
|------------------|------|-------------------------------------|--------------------|--------------------|
| | | Control | Tact | Tact+ |
| Performance | Pre | 3.5573 (1.1232) | 3.5615 (1.1853) | 4.6906 (0.7109) |
| | Post | 3.5812 (1.1139) | 4.2792 (1.0333) | 5.5240 (0.3032) |
| Performance Gain | | 0.0240 (0.6037) | 0.7177 (1.1274) | 0.8333 (0.6632) |
| Teamwork | Pre | 3.4008 (1.0535) | 3.5383 (0.9178) | 4.5608 (0.8671) |
| | Post | 3.5317 (0.9236) | 4.2642 (0.8819) | 5.4225 (0.5573) |
| Teamwork Gain | | 0.1308 (0.5922) | 0.7258 (1.3967) | 0.8617 (0.9237) |

Question one was answered in the affirmative within the data analysis section of the previous chapter. The experimental evidence strongly suggests that once teams are taught adaptation and coordination strategies, their overall performance level and exhibition of teamwork behavior skills are improved upon.

The second question was not fully explored during the data analysis. The focus of the thesis became determining whether or not training had an effect on the teams versus no training. Therefore, the statistical tests were used to measure comparisons to a baseline provided by the control groups vice a comparison at each incremental level of training. However,

from the scoring summary table, it appears that the additional structured information (TAO's sitrep) provided by the tact plus training was beneficial to those teams. On the surface, they consistently appear to rate higher than the tact groups during the experiment.¹⁹

A third research question was: could the experiment provide insight into the decision-making process during stressful periods which could be used to further improve team performance under the test conditions? During the course of the analysis, there was no evidence that the level of stress in the scenarios significantly effected the outcomes.²⁰ Noting that stress does not appear to be a significant factor in the experimental model, we are left with no clear answers regarding performance in low versus high stress scenarios and whether the training significantly impacts one training condition more than the other. We are left to conclude that no additional insight into the decision-making process under

¹⁹ Statistical tests of significance were not conducted between the tact and tact plus groups to confirm that the differences in their apparent scores were not simply a random occurrence.

²⁰ It is the author's opinion that no experimental factors can truly model the stress felt on the high seas. Recognizing this, there is probably no need to try to distinguish between the high and low stress scenarios presented in this study. A ship's company can be just as stressed by a single unknown uncooperative aircraft that may be flying a potentially threatening profile as by five aircraft and a half dozen surface craft operating in the near vicinity which is causing a much greater temporal workload.

stressful conditions "per se" was gained as a result of the experiment.

VI. RECOMMENDATIONS

The purpose of this chapter is to provide recommendations regarding the TACT experiment based upon the finding of the data analysis and personal observations of the author.

A. EXPLORATION OF SCORING DIFFERENCES

During the course of the experiment, different observers were used to rate different teams from the two test sites. As a result of looking at the differences in scores from the two sites; one is left to question if differences in team scores were truly attributable to the test factors or were they attributable to the observers. It is recommended that the contractor review the criteria for assignment of observers and their training to ensure consistency in the subjective evaluation of the teams. It is recognized that any form of subjective evaluation is just that i.e., "subjective" but it is worth reviewing the procedures to ensure that results are not tainted due to biased or partially trained observers.

B. GUARDING AGAINST BIASING THE DECISION-MAKING PROCESS

Teams that the received the tact plus training generally rated higher than the other teams. If the difference in their rating is attributable to the TAO's sitreps, then it is also imperative that an appropriate counter training be provided to ensure that team members are warned that while the sitrep is

a tool to share the TAO's view of the tactical picture, it is not meant to suppress input. Team members must be alert to guard against the confirmatory biasing discussed in Gough's Thesis (Gough, 1992). Operators subordinate to the TAO must be trained that they are to speak out when they disagree with the TAO's analysis for they may be holding a critical piece of information that the TAO may not be aware of in formulating his situational assessment.

TACT EXPERIMENT (TADMUS)

CIC TEAM PRE-MISSION QUESTIONNAIRE

TEAM # _____ SITE _____ DATE _____ TEAM POSITION _____ SCEN # _____

1. How much confidence do you place in the ability of the other members of your team to accomplish this mission?

Very Little 1 2 3 4 5 6 7 A Great Deal

2. How much confidence do you think the other team members place in your ability to accomplish this mission?

Very Little 1 2 3 4 5 6 7 A Great Deal

3. To what extent should team members be aware of other team members workload?

Very Little 1 2 3 4 5 6 7 A Great Deal

4. To what extent do highly competent team members experience stress?

Very Little 1 2 3 4 5 6 7 A Great Deal

5. A team member's decision making ability is as good in stressful situations as it is in non-stressful conditions.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

6. Monitoring the TAO's performance for possible mistakes and errors tends to reduce the TAO's stature and authority.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

7. A team member should offer task help to another team member only if he/she is sure the team member needs it.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

8. To what extent should team members monitor other team members for signs of stress?

Very Little 1 2 3 4 5 6 7 A Great Deal

9. To what extent should team members mention/share their own feelings of stress/workload with other team members during a mission?

Very Little 1 2 3 4 5 6 7 A Great Deal

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10. Even when stressed, I perform effectively during critical aspects of the mission.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

11. To what extent should the team members change their work strategy in response to high stress/workload?

Very Little 1 2 3 4 5 6 7 A Great Deal

12. Communications among team members are rarely affected by high stress/high workload.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

13. To what extent should team members take account of other team members personalities for effective crew coordination?

Very Little 1 2 3 4 5 6 7 A Great Deal

14. To what extent can the effectiveness of crew coordination be lowered by stress/workload?

Very Little 1 2 3 4 5 6 7 A Great Deal

15. It is not a good idea to point out an error committed by a team member during a mission.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

16. To what extent are reprimands more effective than discussions in eliminating some elements of a team member's poor task performance?

Very Little 1 2 3 4 5 6 7 A Great Deal

17. To what extent is understanding the CO's/TAO's concepts/beliefs of the situation/mission important to a team member's execution of the mission?

Very Little 1 2 3 4 5 6 7 A Great Deal

18. Task overload usually occurs because a team member is not very competent.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

19. Each team member should watch for situations in which external events hinder the performance of other team members.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

20. Team members should be able to anticipate each other's information needs during the mission.

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

1/24/94

TACT EXPERIMENT (TADMUS) CIC TEAM POST-MISSION QUESTIONNAIRE

TEAM # _____ SITE _____ DATE _____ TEAM POSITION _____ SCEN # _____

1. How much confidence did you have during the mission that the TAO would successfully complete the mission?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

Very Little Moderate A Great Deal

2. How much confidence did you have during the mission that the other team members would successfully complete the mission?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

Very Little Moderate A Great Deal

3. How much assistance did you provide to other team members as the mission unfolded?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

Very Little Moderate A Great Deal

4. To what extent did you cross-monitor the actions of other team member as the mission unfolded?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

Very Little Moderate A Great Deal

5. To what extent were you able to anticipate (i.e., predict) the actions and decisions of the TAO?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

Rarely Half The Time All The Time

6. To what extent were you able to anticipate (i.e., predict) the actions and decisions of the other team members?

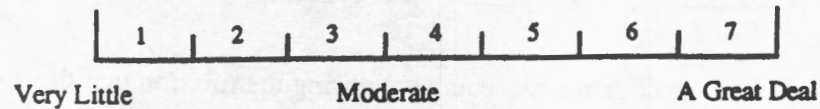
| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

Rarely Half The Time All The Time

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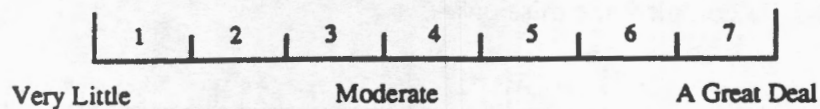
7a. What was the most critical episode of this mission? _____

b. During this episode to what extent were you thinking and acting "in sync" with the TAO?



c. How do you know that? _____

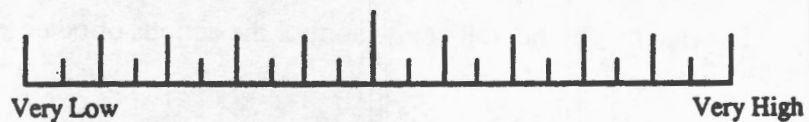
d. During this episode to what extent were you thinking and acting "in sync" with other team members?



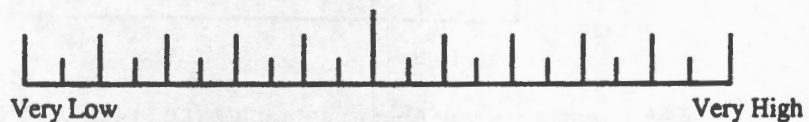
e. How do you know that? _____

Put an "X" on each of the six scales below, at the point that matches best your workload experience for the mission you have just accomplished.

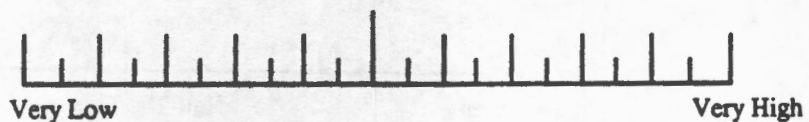
Mental Demand



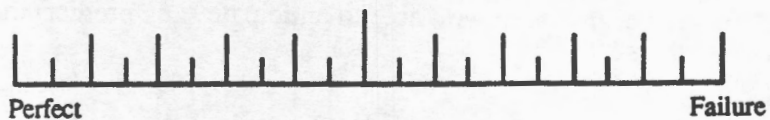
Physical Demand



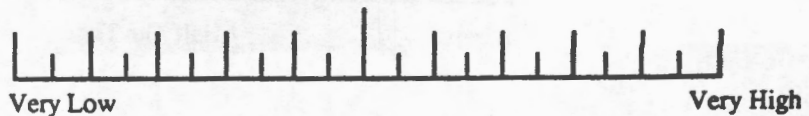
Temporal Demand
(Time Pressure)



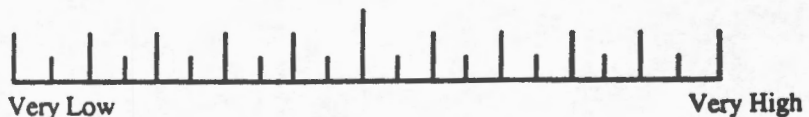
Performance



Effort



Frustration



TACT EXPERIMENT (TADMUS)

TEAMWORK AND PERFORMANCE: OBSERVER'S RATING FORM

TEAM # _____ SITE _____ DATE _____ OBSERVER _____ SCEN # _____

Instructions for Teamwork Ratings

Circle a number on the scale accompanying the questions on the following pages so that it best describes the behavior of the team you just observed. Consider each team separately. Try not to compare one team to another. Instead strive to rate the behavior of a team on an absolute scale. To help you perform this absolute rating a brief description of the behavior you should observe for the highest rating on the scale and a brief description of the behavior you should observe for the lowest rating on the scale are provided for each question. Read these guides or anchors carefully and refer to them as you rate the team on each item. Feel free to write comments or explanations for any question.

The rating scales or questions for teamwork are organized into six areas. To further help you in your ratings each area is defined below. Please read these definitions carefully.

Team Orientation

Team orientation refers to the commitment team members have and exhibit to working together. It implies that they place the goals and interest of the team ahead of their personal goals. It also refers to the trust each team member has in the other team members, team pride, and esprit de corps.

Communication Behavior

Communication involves the exchange of information between two or more team members in the prescribed manner and by using proper terminology. Often the purpose of communication is to clarify or acknowledge the receipt of information.

Monitoring Behavior

Monitoring refers to observing the activities and performance of other team members. It implies that team members are individually competent and that they may subsequently provide feedback and backup behavior.

Feedback Behavior

Feedback involves the giving, seeking, and receiving of information among members. Giving feedback refers to providing information regarding other member's performance. Seeking feedback refers to requesting input or guidance regarding performance. Receiving feedback refers to accepting positive and negative information regarding performance.

Back-up Behavior

Backup behavior involves assisting the performance of other team members. This implies that team members have an understanding of other member's tasks. It also implies that members are willing to give and seek assistance.

Coordination Behavior

Coordination refers to team members' executing their activities in a timely and integrated manner. It implies that the performance of some team members influence the performance of other team members. This may involve an exchange of information that subsequently influences another member's performance.

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Team Orientation

1. To what extent was this team oriented toward teamwork?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Good team orientation could be inferred in a situation where a team member places the goals and interests of the team ahead of personal goals. Also may be evident through the display of trust, team pride, and esprit de corps, and an awareness that teamwork is important.

1 Poor team orientation manifests itself when members place their personal concerns above the team's success (e.g., disregarding or refusing to follow procedures; arguments, quarrels, and open resentment; and becoming upset with a member's performance and either ignoring or harassing that member are evidences of poor team orientation).

2. To what extent were errors caused by inadequate team communication?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Communication within the team was always effective and never responsible for errors or degraded performance.

1 Communication was wholly inadequate and resulted in most of the errors made by the team.

3. To what extent were errors caused by improper individual actions or decisions?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 No actions or decisions of a single team member resulted in errors or poor team performance.

1 The actions and/or decisions by a single team member very frequently resulted in errors or poor team performance.

Comments: _____

Communication Behavior

4. How well did team members communicate?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Good communication occurs when team members pass on all important information and clarify intentions and planned procedures; members obtain necessary information and acknowledge and repeat messages to ensure correctness; members ensure that their messages are received as intended.

1 Poor communication occurs when team members; fail to pass on information or intentions, or pass on incomplete communications; members fail to clarify information; members fail to acknowledge other member's requests or reports; members disregard proper security procedures for communication; members use improper terminology; members tie up the net with irrelevant communications.

5. To what extent did the TAO provide tactical direction or relevant information to other team members, without the other team members having to ask for it?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 TAO always provided important direction or information to other team members without being asked.

1 TAO never provided direction or information to other team members unless specifically asked.

6. To what extent did other team members provide relevant tactical information to the TAO, without the TAO having to ask for it?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Other team members always provided important information to the TAO without being asked.

1 Other team members never provided information to the TAO unless specifically asked.

Comments: _____

Monitoring Behavior

7. To what extent did team members monitor each other's behavior?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Good monitoring occurs when team members consistently observe the performance of the others to ensure the efficiency of the team; members notice and are concerned with the performance of the entire team; one member recognizes when other team members perform correctly; members consistently keep track of other team members' performance.

1 Poor monitoring occurs when team members fail to notice other team members' performance on almost all occasions; members rarely notice when other team members perform correctly or make a mistake.

8. To what extent did team members alert each other to impending decisions and actions?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Team members always alerted each other to impending decisions and actions; supporting information was actively solicited from other team members.

1 Team members did not keep each other informed of impending decisions and actions; compromises to mission safety or mission effectiveness arose when a team member waited for the other to volunteer significant information.

Comments: _____

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Feedback Behavior

9. To what extent did team members provide feedback to one another?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Good feedback behavior occurs when team members go over procedures with one another by identifying mistakes and how to correct them; members ask for input regarding mistakes and what needs to be worked on; members are corrected for mistakes and incorporate the suggestions in their procedures.

1 Poor feedback behavior occurs when one or more team members makes sarcastic comments to one or more members when the scenario doesn't go as planned; members resist asking for advice and make guesses on proper procedures; members reject time-saving suggestions offered by other team members.

Comments: _____

Backup Behavior

10. To what extent did team members provided backup to one another?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Good backup behavior occurs when one team member is having difficulty, makes a mistake, or is unable to perform duties, and one or more members steps in to help, ensuring that the activity is completed properly; one or more members provide critical assistance without neglecting their own assigned duties; the member having difficulty or overburdened displays a willingness to seek assistance rather than struggle and make a mistake.

1 Poor backup behavior occurs when one or more members fail to provide assistance to another member who is having difficulty, makes a mistake, or is unable to perform his duties; while providing assistance, the members tends to neglect their own duties; members are unwilling to ask for help even when it is available; one member provides needed assistance, but does not inform others that he is occupied assisting another or what he has done; one member displays an unwillingness to help others even when asked.

11. To what extent did the TAO anticipate the need to provide (some) assistance to one or more team members?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 TAO consistently anticipated the need to provide assistance to other team members during critical phases of the mission.

1 TAO never anticipated the need to provide assistance to other team members during critical phases of the mission; the other team members always had to ask.

12. To what extend did the other team members anticipate the need to provide assistance to the TAO?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Other team members consistently anticipated the need to provide assistance to the TAO during critical phases of the mission.

1 Other team members never anticipated the need to provide assistance to the TAO during critical phases of the mission; the TAO always had to ask.

13. Did the team members adjust individual task responsibilities to prevent overload?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Team members were consistently aware of each other's workload buildup and reacted quickly to adjust division of task responsibilities to redistribute workload .

1 Team members were generally unaware of each other's workload buildup; little or no attempt was made to adjust the distribution of task responsibilities before significant compromises to mission safety or mission effectiveness occurred.

Comments: _____

Coordination Behavior

14. To what extent was the team's behavior coordinated?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 Good coordination behavior occurs when team members consistently pass critical information to the other members, thereby enabling them to accomplish tasks; members consistently carry out tasks quickly or in a timely manner enabling others to carry out their tasks effectively. Team members appear very familiar with the relevant parts of one another's jobs and carry out individual tasks in a synchronized manner.

1 Poor coordination behavior occurs when team members consistently carry out their tasks ineffectively, leading to other team members' failing at their tasks; members carry out their tasks unpredictably, leading to delays in execution of critical tasks; members neglect to pass on critical pieces of information to one another, leading to breakdowns in team performance; team members carry out their tasks with significant delays leading to team errors.

15. How congruent/similar were the TAO's and the other team members' understanding of the mission?

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7 TAO and other team members were completely in agreement (i.e., congruent) on goals, tasks, and concepts involving the mission.

1 TAO and other team members were rarely in agreement (i.e., congruent) on goals, tasks, and concepts involving the mission.

Comments: _____

OVERALL AAW TEAM PERFORMANCE ASSESSMENT

Instructions for Performance Ratings

Please assess the performance of the team for the following tasks and/or activities using the scales provided. Note that a score of 7 always denotes effective or superior performance, while a score of 1 always denotes ineffective or very poor performance. The anchors or descriptors associated with the high and low scores are what you should expect to see for very effective and very ineffective team performances, respectively. They are provided as guidance for your ratings.

1. Making radar detection reports. This refers to the report made by any team member who verbally describes the radar contact.

| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|
|-----------|---|---|---|---|---|---|---|----------|

7 The radar detection reports are always accurate, concise, and timely. Proper format (e.g., APP-1, NWP-32) and terminology are always used.

1 Some radar detections are never reported. Many reports are inaccurate and late. Often proper format and terminology are not used.

2. Making ESM detection reports. This refers to verbal reports of ESM detections.

| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|
|-----------|---|---|---|---|---|---|---|----------|

7 The ESM detection reports are always accurate, concise, and timely. Proper format and terminology are always used.

1 Some ESM detections are never reported. Many reports are inaccurate and late. Often proper format and terminology are not used.

3. Identification/Correlation reports. This refers to verbal reports of the correlation and identification of contacts.

| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|
|-----------|---|---|---|---|---|---|---|----------|

7 The ID/Correlation reports are always accurate, concise, and timely. Proper format and terminology are always used.

1 Some ID/Correlations are never made and/or reported. Many reports contain errors and/or are late. Frequently improper format and incorrect terminology are used.

4. Assessment of contacts' hostile intent. This is typically based on input from lower levels within the team and made by the TAO or CO.

| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|
|-----------|---|---|---|---|---|---|---|----------|

7 TAO/CO routinely assess the threat of each new contact and advise the rest of the team accordingly. Assessment is firmly based on information the team has collected (e.g., ESM, ID/Corr, Intel) and on verbal discussions concerned with weapons loads, flight profiles, and attempts at communication with the contact.

1 TAO/CO infrequently assess the threat of new contacts and/or rarely advise the rest of the team as to the contact's threat. Assessment is often not based on available information and verbal discussion about such aspects as weapons load and flight profile have not occurred.

5. Monitoring the threat. This pertains primarily to critical contacts of interest (CCOI).

Very Poor 1 2 3 4 5 6 7 Superior

7 CCOIs are frequently hooked and observation of them are more or less constant. The status of the CCOIs are frequently discussed and appraised - in short the intensity of involvement with these threats is high.

1 CCOIs are frequently neglected or overlooked. The status of CCPIs are not reviewed, discussed, or appraised frequently enough - in short, the intensity of involvement with these threats is low.

6. Taking appropriate action in accordance with ROE. This refers to whether the team decides to take some action against a given CCOI vs. failure to do anything about it.

Very Poor 1 2 3 4 5 6 7 Superior

7 TAO (or CO) and team consistently take effective and appropriate actions to deal with threats. This includes assigning CAP, covering, issuing verbal warnings, increasing readiness/going to GQ, activating doctrine, and determining chaff solutions.

1 TAO (or CO) and team are lax and often fail to take effective or appropriate actions to deal with threats. They tend to over react or fails to react.

7. Planning for the upcoming mission. This refers to all planning activities performed by the TAO or other team members for the upcoming mission.

Very Poor 1 2 3 4 5 6 7 Superior

7 The TAO and/or other team members spend a reasonable amount of time planning for the upcoming mission. Roles are further defined and tasks that are outside normal responsibility assigned. Critical events that might occur are clearly defined and specific responses agreed upon.

1 The TAO and/or other team members spend little or no time planning for the upcoming mission. Roles are not further defined and tasks that are outside normal responsibility are not assigned. Little or no discussion occurs about critical events that might occur. Those events that are mentioned are not defined well nor are responses to the events delineated.

8. Overall performance rating of this team for this scenario.

Very Poor 1 2 3 4 5 6 7 Superior

7 Superior teams have consistently scored well on the above six areas, as well as on other unassessed areas.

1 Poor teams have consistently scored poorly on the above six areas, as well as on other unassessed areas.

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9. Performance of critical events. Below are four critical events that occurred in this scenario. Rate how the team performed each on the seven point scales provided.

a. Four Iranian F4s detected .

| | | | | | | | | |
|-----------|---|---|---|---|---|---|---|----------|
| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|

b. Iranian bogies split into two sections.

| | | | | | | | | |
|-----------|---|---|---|---|---|---|---|----------|
| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|

c. APQ120 detected (Iranian F4).

| | | | | | | | | |
|-----------|---|---|---|---|---|---|---|----------|
| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|

d. Low F4s pop-up at 46nm.

| | | | | | | | | |
|-----------|---|---|---|---|---|---|---|----------|
| Very Poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Superior |
|-----------|---|---|---|---|---|---|---|----------|

TACT EXPERIMENT (TADMUS)
CIC TEAM COMMUNICATION RECORDING FORM: TAO

TEAM # _____ SITE _____ DATE _____ OBSERVER _____ SCEN # _____ PERIOD 1 2 3

| TYPE & CONTENT | | TAO to: | | | | | |
|-----------------|----------------------------|---------|-----|------|-----|-----|-----|
| | | TIC | IDS | AAWC | EWS | All | Out |
| REQUESTS | INFORMATION | | | | | | |
| | ACTION & TASK | | | | | | |
| | PROBLEM SOLVING & PLANNING | | | | | | |
| TRANSFERS | INFORMATION | | | | | | |
| | ACTION & TASK | | | | | | |
| | PROBLEM SOLVING & PLANNING | | | | | | |
| ACKNOWLEDGMENTS | | | | | | | |

Additional notes / Other categories:

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TACT EXPERIMENT (TADMUS) CIC TEAM COMMUNICATION RECORDING FORM: Team

TEAM # _____ SITE _____ DATE _____ OBSERVER _____ SCEN # _____ PERIOD 1 2 3

| TYPE & CONTENT | | TIC to: | | IDS to: | | AAWC to: | | EWS to: | | Team to: |
|-----------------|----------------------------|---------|------|---------|------|----------|------|---------|------|----------|
| | | TAO | Team | TAO | Team | TAO | Team | TAO | Team | Out |
| REQUESTS | INFORMATION | | | | | | | | | |
| | ACTION & TASK | | | | | | | | | |
| | PROBLEM SOLVING & PLANNING | | | | | | | | | |
| TRANSFERS | INFORMATION | | | | | | | | | |
| | ACTION & TASK | | | | | | | | | |
| | PROBLEM SOLVING & PLANNING | | | | | | | | | |
| ACKNOWLEDGMENTS | | | | | | | | | | |

Additional notes / Other categories:

APPENDIX B. DATA SPREADSHEETS

TACT DATA SPREADSHEET

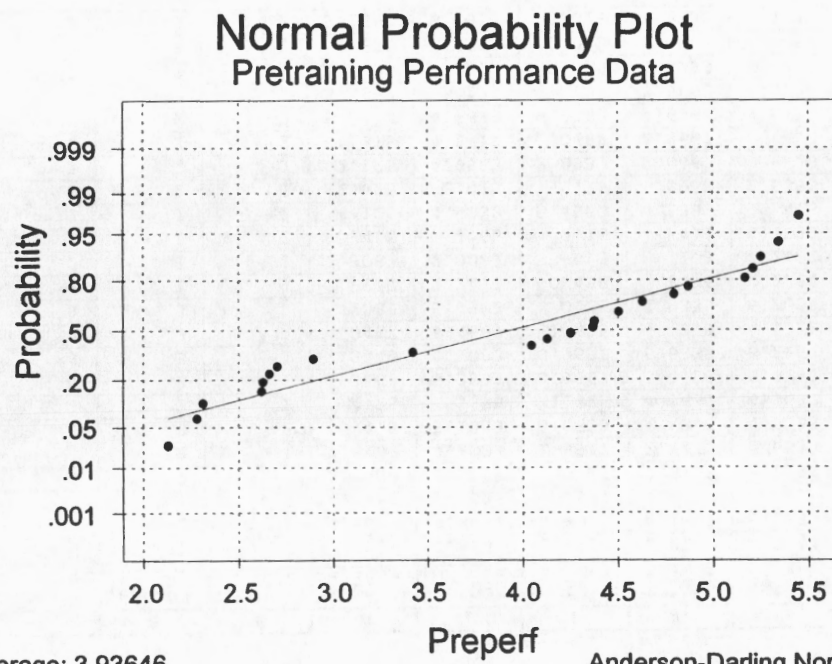
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q |
|--------|----------|---------|----------|----------|------------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| 1 site | exp cond | team ID | pre/post | scenario | stress lvl | trial # | tmwk 1 | tmwk 2 | tmwk 3 | tmwk 4 | tmwk 5 | tmwk 6 | tmwk 7 | tmwk 8 | tmwk 9 | tmwk 10 |
| 2 | 1 | 2 | 1 | 1 | 1 | 1 | 4 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 3 |
| 3 | 1 | 2 | 1 | 1 | 2 | 2 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 4 |
| 4 | 1 | 2 | 1 | 1 | 1 | 1 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 4 |
| 5 | 1 | 2 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| 6 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| 7 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| 8 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| 9 | 1 | 2 | 1 | 1 | 2 | 2 | 4 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 |
| 10 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 11 | 1 | 3 | 3 | 1 | 1 | 2 | 1 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 12 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 13 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 14 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 15 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 16 | 1 | 3 | 3 | 1 | 1 | 1 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 17 | 1 | 3 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 18 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 20 | 1 | 3 | 3 | 1 | 1 | 1 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 21 | 1 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 22 | 1 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 23 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 24 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 25 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 26 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 28 | 1 | 3 | 3 | 1 | 1 | 1 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 29 | 1 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
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| 31 | 1 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 32 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 33 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 34 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 35 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 36 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
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| 39 | 1 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
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| 41 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 42 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 43 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 44 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 45 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 46 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 47 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 48 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 49 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

TACT DATA SPREADSHEET

| | R | S | T | U | V | W | X | Y | Z | AA | AB | AC | AD | AE | AF | AG | AH |
|----|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|
| | tmwk 11 | tmwk 12 | tmwk 13 | tmwk 14 | tmwk 15 | perf 1 | perf 2 | perf 3 | perf 4 | perf 5 | perf 6 | perf 7 | perf 8 | perf 9a | perf 9b | perf 9c | perf 9d |
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| 6 | 2.5 | 3.5 | 3 | 2.8 | 2.3 | 2.5 | 3 | 2.3 | 2.8 | 2 | 1.5 | 3.5 | 2.8 | 3 | 1.5 | 1.5 | 4 |
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| 9 | 4 | 4.5 | 4.5 | 4.3 | 5 | 3.8 | 4 | 4 | 5 | 4 | 2.8 | 3.5 | 3.3 | 2.5 | 2.5 | 3.3 | 5.5 |
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| 11 | 6.3 | 5.3 | 6 | 6.3 | 6.3 | 4 | 6 | 6 | 6 | 5.5 | 5.5 | 5.8 | 6 | 6 | 4 | 6 | 4.5 |
| 12 | 5.5 | 6 | 5.5 | 5.5 | 5.8 | 5.5 | 5.8 | 5.8 | 5.5 | 5.5 | 5.5 | 5.8 | 5.5 | 5.3 | 5.5 | 4 | 6 |
| 13 | 1.5 | 2.3 | 1.8 | 1.8 | 2 | 2 | 2.3 | 1.8 | 1.8 | 2.5 | 2.5 | 2 | 1.8 | 1.8 | 2.8 | 2.5 | 1.8 |
| 14 | 1.8 | 2 | 1.5 | 2 | 1.8 | 2 | 2 | 4 | 1.8 | 1.5 | 2.5 | 1.8 | 1.8 | 1.8 | 1.5 | 4 | 2.5 |
| 15 | 5 | 3.8 | 3.3 | 3.8 | 3.3 | 3.3 | 4.5 | 4 | 2.8 | 3.3 | 3.5 | 2.8 | 3.5 | 2.8 | 3 | 4 | 5.3 |
| 16 | 2 | 2 | 2.5 | 1.8 | 1.8 | 2 | 3 | 1.8 | 1.8 | 1.8 | 1.5 | 2.3 | 2 | 1.5 | 2.3 | 2.8 | 1.3 |
| 17 | 4.3 | 5.8 | 6 | 5.8 | 5.8 | 4 | 5.5 | 6 | 6.3 | 5.5 | 5.5 | 6 | 5 | 5.8 | 6 | 4.5 | 6.3 |
| 18 | 5.5 | 6.3 | 5.5 | 5.5 | 5.5 | 5 | 5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 4 | 4 | 6 | 6 |
| 19 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.5 | 6.5 | 6.5 | 6.3 | 6.5 | 6.5 | 6.5 | 6.3 | 4 | 6.3 | 6.3 |
| 20 | 4.8 | 6.3 | 6.3 | 6 | 5.5 | 5.5 | 6 | 6.3 | 6.3 | 5.5 | 5.8 | 6 | 6 | 6.3 | 4.3 | 3.5 | 6 |
| 21 | 2.5 | 2.5 | 2 | 2.3 | 2.3 | 2.5 | 3 | 2.3 | 2.8 | 2.5 | 3 | 2.5 | 2.5 | 2 | 2.3 | 2.5 | 3.5 |
| 22 | 2 | 2 | 1.5 | 1.5 | 2 | 2 | 1.5 | 2 | 2 | 1.8 | 2.5 | 1.8 | 2 | 1.8 | 1.8 | 3 | 3.3 |
| 23 | 4.5 | 4.5 | 4.8 | 4.8 | 5.5 | 4.5 | 3.5 | 4.8 | 4.8 | 4.5 | 4.5 | 5.3 | 4.5 | 3.5 | 3.8 | 1.5 | 5.3 |
| 24 | 5.5 | 5 | 5.3 | 5.5 | 5.5 | 5 | 3.8 | 5 | 5.3 | 4.8 | 5.5 | 5.5 | 5 | 5.5 | 3.8 | 4.8 | 5.5 |
| 25 | 4.5 | 3.5 | 2.5 | 4 | 5.5 | 2.5 | 5.5 | 4 | 5 | 5.5 | 5.5 | 4 | 5.5 | 3.5 | 3.5 | 4.5 | 5 |
| 26 | 5 | 3 | 3 | 4 | 5 | 3 | 5.5 | 3.5 | 4.5 | 5.5 | 5.5 | 4.5 | 4 | 3.5 | 2.5 | 5 | 5.5 |
| 27 | 5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.3 | 6 | 4 | 5.5 | 5 | 5.5 | 5 | 5.3 | 5.5 | 4.8 | 4.8 | 5.5 |
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| 38 | 4 | 4 | 3 | 4.5 | 4.5 | 4.5 | 5.5 | 5 | 3.5 | 3.5 | 3 | 3.5 | 4 | 5 | 5 | 3 | 3 |
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| 43 | 3.5 | 3.5 | 4 | 4.5 | 4.5 | 4.5 | 4.5 | 3.5 | 4 | 3.5 | 4.5 | 3.5 | 4.5 | 3 | 3.5 | 5 | 4 |
| 44 | 4 | 4 | 4.5 | 4.5 | 5 | 4.5 | 5.5 | 6 | 4 | 5 | 5.5 | 4 | 4.8 | 3 | 2.5 | 5 | 6 |
| 45 | 4 | 4.5 | 4 | 5 | 5 | 4.5 | 6 | 3 | 4 | 5.5 | 5.5 | 4 | 4.5 | 4 | 5 | 5.5 | 3.5 |
| 46 | 4 | 4.5 | 4 | 5.5 | 5.5 | 5.5 | 4.5 | 5.5 | 5.5 | 5.5 | 5.5 | 4.5 | 6 | 6 | 4.5 | 3.5 | 6 |
| 47 | 4 | 5 | 4.5 | 6.5 | 5.5 | 6 | 4.5 | 5.5 | 5 | 6 | 5.5 | 5.5 | 5 | 4 | 4 | 5.5 | 5 |
| 48 | 4 | 6 | 4.5 | 6 | 5.5 | 6.5 | 5 | 6 | 5.5 | 5.5 | 5.5 | 4.5 | 6 | 6.5 | 3 | 5 | 6.5 |
| 49 | 4 | 4 | 4 | 5.8 | 5 | 5.5 | 5 | 4.5 | 6 | 5 | 5.8 | 4.5 | 5.5 | 5 | 4.5 | 6 | 5 |

MODIFIED DATA SPREADSHEET

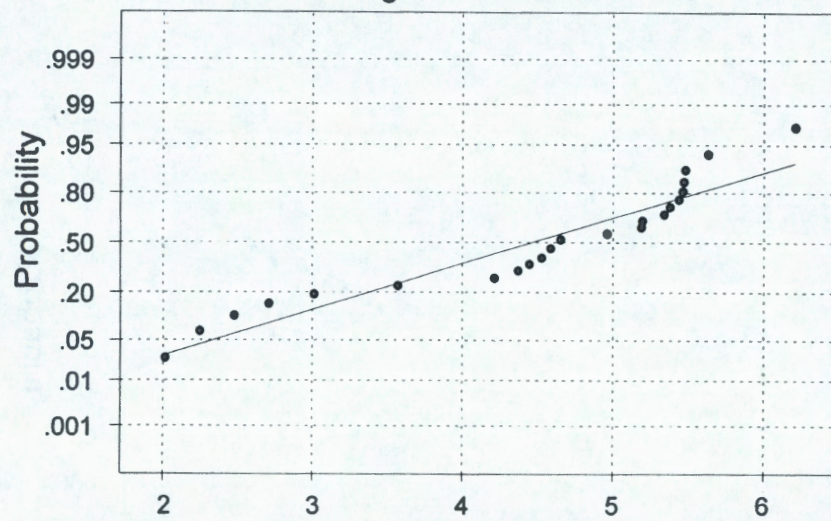
| | A | B | C | D | E | F | G | H | I |
|----|--------|---------|------|---------|----------|----------|---------|----------|----------|
| 1 | Stress | Expcond | Site | Preperf | Postperf | Perfgain | Pretmwk | Posttmwk | Tmwkgain |
| 2 | 1 | 1 | 1 | 2.8917 | 2.7083 | -0.183 | 3.4533 | 2.8867 | -0.567 |
| 3 | 1 | 1 | 1 | 2.275 | 3.5667 | 1.2917 | 2.0267 | 3.44 | 1.4133 |
| 4 | 1 | 1 | 2 | 4.8667 | 4.3667 | -0.5 | 4.1667 | 4.3333 | 0.1667 |
| 5 | 1 | 1 | 2 | 4.7917 | 4.525 | -0.267 | 4.6667 | 4.3 | -0.367 |
| 6 | 1 | 2 | 1 | 2.6583 | 3.0083 | 0.35 | 3.5733 | 3.2133 | -0.36 |
| 7 | 1 | 2 | 1 | 2.6167 | 4.2083 | 1.5917 | 2.3133 | 4.6533 | 2.34 |
| 8 | 1 | 2 | 2 | 4.5 | 5.1833 | 0.6833 | 3.8 | 4.5533 | 0.7533 |
| 9 | 1 | 2 | 2 | 4.25 | 5.375 | 1.125 | 4.3667 | 4.8667 | 0.5 |
| 10 | 1 | 3 | 1 | 4.3667 | 5.3333 | 0.9667 | 4.28 | 6.0267 | 1.7467 |
| 11 | 1 | 3 | 1 | 5.45 | 6.2083 | 0.7583 | 5.5333 | 6.2267 | 0.6933 |
| 12 | 1 | 3 | 2 | 4.0417 | 5.4667 | 1.425 | 3.9 | 5.12 | 1.22 |
| 13 | 1 | 3 | 2 | 5.2083 | 5.4583 | 0.25 | 4.9333 | 5.2067 | 0.2733 |
| 14 | 2 | 1 | 1 | 2.7 | 2.2417 | -0.458 | 2.76 | 2.64 | -0.12 |
| 15 | 2 | 1 | 1 | 2.3083 | 2.0083 | -0.3 | 1.9 | 2.02 | 0.12 |
| 16 | 2 | 1 | 2 | 4.5 | 4.65 | 0.15 | 4.1 | 4.3333 | 0.2333 |
| 17 | 2 | 1 | 2 | 4.125 | 4.5833 | 0.4583 | 4.1333 | 4.3 | 0.1667 |
| 18 | 2 | 2 | 1 | 2.625 | 2.475 | -0.15 | 3.5933 | 2.6333 | -0.96 |
| 19 | 2 | 2 | 1 | 2.125 | 4.9583 | 2.8333 | 2.0467 | 5.26 | 3.2133 |
| 20 | 2 | 2 | 2 | 4.375 | 4.4417 | 0.0667 | 3.9667 | 4.4 | 0.4333 |
| 21 | 2 | 2 | 2 | 5.3417 | 4.5833 | -0.758 | 4.6467 | 4.5333 | -0.113 |
| 22 | 2 | 3 | 1 | 3.4167 | 5.475 | 2.0583 | 3.5667 | 5.76 | 2.1933 |
| 23 | 2 | 3 | 1 | 5.25 | 5.625 | 0.375 | 5.5733 | 5.5333 | -0.04 |
| 24 | 2 | 3 | 2 | 4.625 | 5.4333 | 0.8083 | 3.4667 | 4.7867 | 1.32 |
| 25 | 2 | 3 | 2 | 5.1667 | 5.1917 | 0.025 | 5.2333 | 4.72 | -0.513 |



Average: 3.93646
Std Dev: 1.12344
N of data: 24

Anderson-Darling Normality Test
A-Squared: 0.957
p-value: 0.013

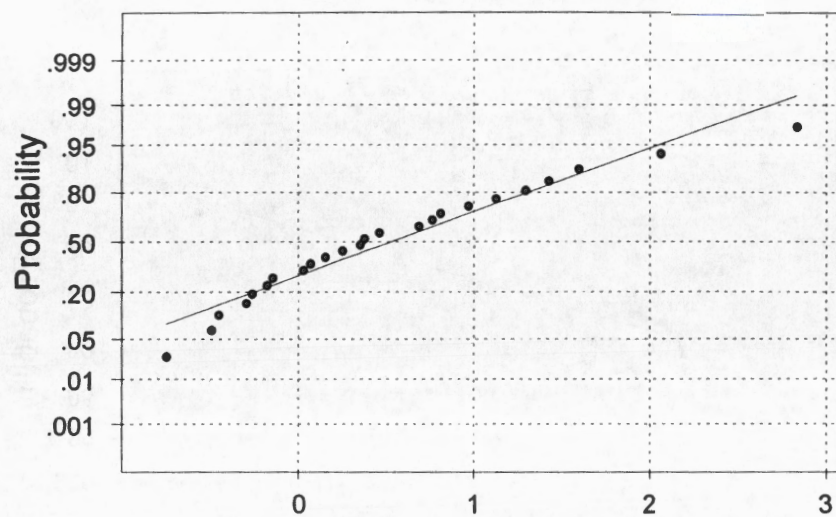
Normal Probability Plot Posttraining Performance Data



Average: 4.46146
Std Dev: 1.18500
N of data: 24

Anderson-Darling Normality Test
A-Squared: 1.069
p-value: 0.007

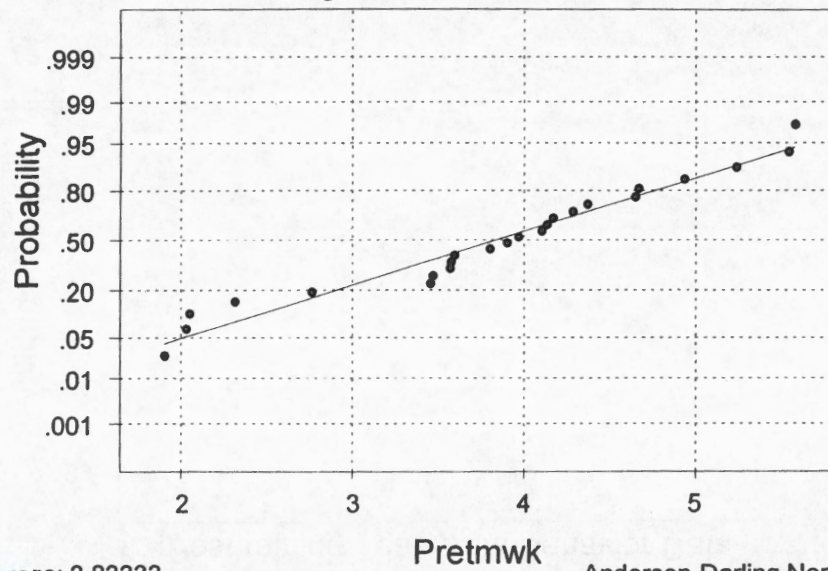
Normal Probability Plot Performance Gain Data



Average: 0.525
Std Dev: 0.874594
N of data: 24

Anderson-Darling Normality Test
A-Squared: 0.368
p-value: 0.401

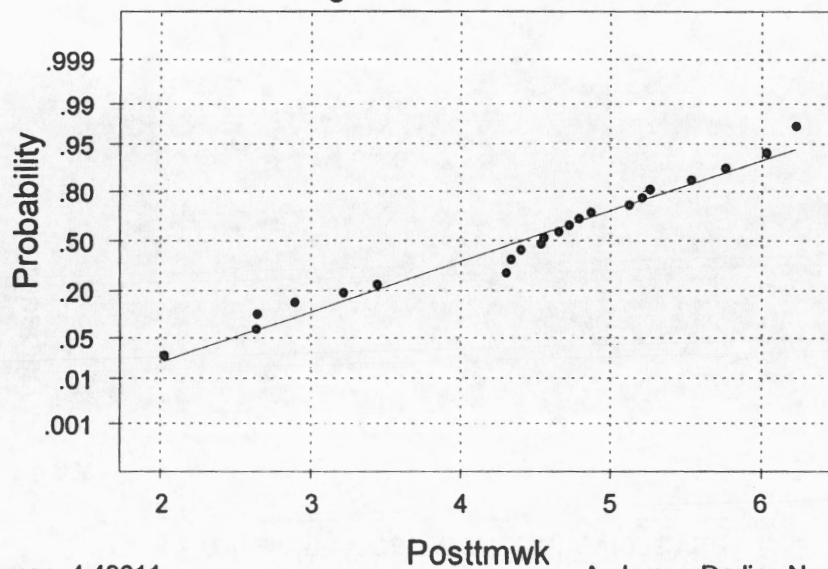
Normal Probability Plot Pretraining Teamwork Behavior Data



Average: 3.83333
Std Dev: 1.04994
N of data: 24

Anderson-Darling Normality Test
A-Squared: 0.411
p-value: 0.316

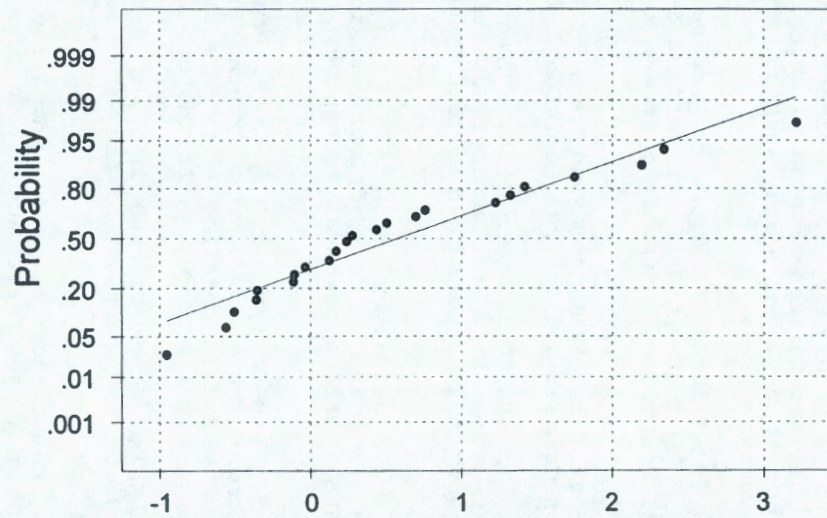
Normal Probability Plot Posttraining Teamwork Behavior Data



Average: 4.40611
Std Dev: 1.10595
N of data: 24

Anderson-Darling Normality Test
A-Squared: 0.549
p-value: 0.141

Normal Probability Plot Teamwork Behavior Gain Data



Average: 0.572778
Std Dev: 1.03212
N of data: 24

Anderson-Darling Normality Test
A-Squared: 0.643
p-value: 0.082

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Telephone conversation between Dr. E. Entin, Alphatech, INC. and the author, 3 May 1994.

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